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(54) Title: <i>NEISSERIA MENINGITIDIS</i> ANTIGENS (57) Abstract The invention provides proteins from <i>Neisseria meningitidis</i> (strains A and B), including amino acid sequences, the corresponding nucleotide sequences, expression data, and serological data. The proteins are useful antigens for vaccines, immunogenic compositions, and/or diagnostics.		

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NEISSERIA MENINGITIDIS ANTIGENS

This invention relates to antigens from the bacterium *Neisseria meningitidis*.

BACKGROUND

Neisseria meningitidis is a non-motile, gram negative diplococcus human pathogen. It colonises the pharynx, causing meningitis and, occasionally, septicaemia in the absence of meningitis. It is closely related to *N.gonorrhoeae*, although one feature that clearly differentiates meningococcus from gonococcus is the presence of a polysaccharide capsule that is present in all pathogenic meningococci.

N.meningitidis causes both endemic and epidemic disease. In the United States the attack rate is 0.6-1 per 100,000 persons per year, and it can be much greater during outbreaks (see Lieberman *et al.* (1996) Safety and Immunogenicity of a Serogroups A/C *Neisseria meningitidis* Oligosaccharide-Protein Conjugate Vaccine in Young Children. *JAMA* 275(19):1499-1503; Schuchat *et al* (1997) Bacterial Meningitis in the United States in 1995. *N Engl J Med* 337(14):970-976). In developing countries, endemic disease rates are much higher and during epidemics incidence rates can reach 500 cases per 100,000 persons per year. Mortality is extremely high, at 10-20% in the United States, and much higher in developing countries. Following the introduction of the conjugate vaccine against *Haemophilus influenzae*, *N. meningitidis* is the major cause of bacterial meningitis at all ages in the United States (Schuchat *et al* (1997) *supra*).

Based on the organism's capsular polysaccharide, 12 serogroups of *N.meningitidis* have been identified. Group A is the pathogen most often implicated in epidemic disease in sub-Saharan Africa. Serogroups B and C are responsible for the vast majority of cases in the United States and in most developed countries. Serogroups W135 and Y are responsible for the rest of the cases in the United States and developed countries. The meningococcal vaccine currently in use is a tetravalent polysaccharide vaccine composed of serogroups A, C, Y and W135. Although efficacious in adolescents and adults, it induces a poor immune response and short duration of protection, and cannot be used in infants [eg. Morbidity and Mortality weekly report, Vol.46, No. RR-5 (1997)]. This is because polysaccharides are T-cell independent antigens that induce a weak immune response that cannot be boosted by repeated immunization. Following the success of the

vaccination against *H.influenzae*, conjugate vaccines against serogroups A and C have been developed and are at the final stage of clinical testing (Zollinger WD "New and Improved Vaccines Against Meningococcal Disease" in: *New Generation Vaccines, supra*, pp. 469-488; Lieberman *et al* (1996) *supra*; Costantino *et al* (1992) Development and phase I clinical testing of a conjugate vaccine against meningococcus A and C. *Vaccine* 10:691-698).

Meningococcus B remains a problem, however. This serotype currently is responsible for approximately 50% of total meningitis in the United States, Europe, and South America. The polysaccharide approach cannot be used because the menB capsular polysaccharide is a polymer of $\alpha(2-8)$ -linked *N*-acetyl neuraminic acid that is also present in mammalian tissue. This results in tolerance to the antigen; indeed, if an immune response were elicited, it would be anti-self, and therefore undesirable. In order to avoid induction of autoimmunity and to induce a protective immune response, the capsular polysaccharide has, for instance, been chemically modified substituting the *N*-acetyl groups with *N*-propionyl groups, leaving the specific antigenicity unaltered (Romero & Outschoorn (1994) Current status of Meningococcal group B vaccine candidates: capsular or non-capsular? *Clin Microbiol Rev* 7(4):559-575).

Alternative approaches to menB vaccines have used complex mixtures of outer membrane proteins (OMPs), containing either the OMPs alone, or OMPs enriched in porins, or deleted of the class 4 OMPs that are believed to induce antibodies that block bactericidal activity. This approach produces vaccines that are not well characterized. They are able to protect against the homologous strain, but are not effective at large where there are many antigenic variants of the outer membrane proteins. To overcome the antigenic variability, multivalent vaccines containing up to nine different porins have been constructed (eg. Poolman JT (1992) Development of a meningococcal vaccine. *Infect. Agents Dis.* 4:13-28). Additional proteins to be used in outer membrane vaccines have been the opa and opc proteins, but none of these approaches have been able to overcome the antigenic variability (eg. Ala'Aldeen & Borriello (1996) The meningococcal transferrin-binding proteins 1 and 2 are both surface exposed and generate bactericidal antibodies capable of killing homologous and heterologous strains. *Vaccine* 14(1):49-53).

A certain amount of sequence data is available for meningococcal and gonococcal genes and proteins (eg. EP-A-0467714, WO96/29412), but this is by no means complete. The provision of further sequences could provide an opportunity to identify secreted or surface-exposed proteins that

are presumed targets for the immune system and which are not antigenically variable. For instance, some of the identified proteins could be components of efficacious vaccines against meningococcus B, some could be components of vaccines against all meningococcal serotypes, and others could be components of vaccines against all pathogenic *Neisseriae*.

5 THE INVENTION

The invention provides proteins comprising the *N.meningitidis* amino acid sequences disclosed in the examples.

It also provides proteins comprising sequences homologous (*ie.* having sequence identity) to the *N.meningitidis* amino acid sequences disclosed in the examples. Depending on the particular
10 sequence, the degree of sequence identity is preferably greater than 50% (*eg.* 60%, 70%, 80%, 90%, 95%, 99% or more). These homologous proteins include mutants and allelic variants of the sequences disclosed in the examples. Typically, 50% identity or more between two proteins is considered to be an indication of functional equivalence. Identity between the proteins is preferably determined by the Smith-Waterman homology search algorithm as implemented in the MPSRCH
15 program (Oxford Molecular), using an affine gap search with parameters *gap open penalty=12* and *gap extension penalty=1*.

The invention further provides proteins comprising fragments of the *N.meningitidis* amino acid sequences disclosed in the examples. The fragments should comprise at least *n* consecutive amino acids from the sequences and, depending on the particular sequence, *n* is 7 or more (*eg.* 8, 10, 12,
20 14, 16, 18, 20 or more). Preferably the fragments comprise an epitope from the sequence.

The proteins of the invention can, of course, be prepared by various means (*eg.* recombinant expression, purification from cell culture, chemical synthesis *etc.*) and in various forms (*eg.* native, fusions *etc.*). They are preferably prepared in substantially pure form (*ie.* substantially free from other *N.meningitidis* or host cell proteins)

25 According to a further aspect, the invention provides antibodies which bind to these proteins. These may be polyclonal or monoclonal and may be produced by any suitable means.

According to a further aspect, the invention provides nucleic acid comprising the *N.meningitidis* nucleotide sequences disclosed in the examples. In addition, the invention provides nucleic acid comprising sequences homologous (*ie.* having sequence identity) to the *N.meningitidis* nucleotide sequences disclosed in the examples.

- 5 Furthermore, the invention provides nucleic acid which can hybridise to the *N.meningitidis* nucleic acid disclosed in the examples, preferably under "high stringency" conditions (*eg.* 65°C in a 0.1xSSC, 0.5% SDS solution).

- Nucleic acid comprising fragments of these sequences are also provided. These should comprise at least *n* consecutive nucleotides from the *N.meningitidis* sequences and, depending on the
10 particular sequence, *n* is 10 or more (*eg.* 12, 14, 15, 18, 20, 25, 30, 35, 40 or more).

According to a further aspect, the invention provides nucleic acid encoding the proteins and protein fragments of the invention.

It should also be appreciated that the invention provides nucleic acid comprising sequences complementary to those described above (*eg.* for antisense or probing purposes).

- 15 Nucleic acid according to the invention can, of course, be prepared in many ways (*eg.* by chemical synthesis, from genomic or cDNA libraries, from the organism itself *etc.*) and can take various forms (*eg.* single stranded, double stranded, vectors, probes *etc.*).

In addition, the term "nucleic acid" includes DNA and RNA, and also their analogues, such as those containing modified backbones, and also peptide nucleic acids (PNA) *etc.*

- 20 According to a further aspect, the invention provides vectors comprising nucleotide sequences of the invention (*eg.* expression vectors) and host cells transformed with such vectors.

According to a further aspect, the invention provides compositions comprising protein, antibody, and/or nucleic acid according to the invention. These compositions may be suitable as vaccines, for instance, or as diagnostic reagents, or as immunogenic compositions.

The invention also provides nucleic acid, protein, or antibody according to the invention for use as medicaments (eg. as vaccines) or as diagnostic reagents. It also provides the use of nucleic acid, protein, or antibody according to the invention in the manufacture of: (i) a medicament for treating or preventing infection due to Neisserial bacteria; (ii) a diagnostic reagent for detecting the presence of Neisserial bacteria or of antibodies raised against Neisserial bacteria; and/or (iii) a reagent which can raise antibodies against Neisserial bacteria. Said Neisserial bacteria may be any species or strain (such as *N.gonorrhoeae*) but are preferably *N.meningitidis*, especially strain A, strain B or strain C.

The invention also provides a method of treating a patient, comprising administering to the patient a therapeutically effective amount of nucleic acid, protein, and/or antibody according to the invention.

According to further aspects, the invention provides various processes.

A process for producing proteins of the invention is provided, comprising the step of culturing a host cell according to the invention under conditions which induce protein expression.

A process for producing protein or nucleic acid of the invention is provided, wherein the protein or nucleic acid is synthesised in part or in whole using chemical means.

A process for detecting polynucleotides of the invention is provided, comprising the steps of: (a) contacting a nucleic probe according to the invention with a biological sample under hybridizing conditions to form duplexes; and (b) detecting said duplexes.

A process for detecting proteins of the invention is provided, comprising the steps of: (a) contacting an antibody according to the invention with a biological sample under conditions suitable for the formation of an antibody-antigen complexes; and (b) detecting said complexes.

Unlike the sequences disclosed in PCT/IB98/01665, the sequences disclosed in the present application are believed not to have any significant homologs in *N.gonorrhoeae*. Accordingly, the sequences of the present invention also find use in the preparation of reagents for distinguishing between *N.meningitidis* and *N.gonorrhoeae*

A summary of standard techniques and procedures which may be employed in order to perform the invention (eg. to utilise the disclosed sequences for vaccination or diagnostic purposes) follows. This summary is not a limitation on the invention but, rather, gives examples that may be used, but are not required.

5 General

- The practice of the present invention will employ, unless otherwise indicated, conventional techniques of molecular biology, microbiology, recombinant DNA, and immunology, which are within the skill of the art. Such techniques are explained fully in the literature eg. Sambrook *Molecular Cloning; A Laboratory Manual, Second Edition* (1989); *DNA Cloning, Volumes I and*
10 *ii* (D.N. Glover ed. 1985); *Oligonucleotide Synthesis* (M.J. Gait ed, 1984); *Nucleic Acid Hybridization* (B.D. Hames & S.J. Higgins eds. 1984); *Transcription and Translation* (B.D. Hames & S.J. Higgins eds. 1984); *Animal Cell Culture* (R.I. Freshney ed. 1986); *Immobilized Cells and Enzymes* (IRL Press, 1986); B. Perbal, *A Practical Guide to Molecular Cloning* (1984); the *Methods in Enzymology* series (Academic Press, Inc.), especially volumes 154 & 155; *Gene*
15 *Transfer Vectors for Mammalian Cells* (J.H. Miller and M.P. Calos eds. 1987, Cold Spring Harbor Laboratory); Mayer and Walker, eds. (1987), *Immunochemical Methods in Cell and Molecular Biology* (Academic Press, London); Scopes, (1987) *Protein Purification: Principles and Practice*, Second Edition (Springer-Verlag, N.Y.), and *Handbook of Experimental Immunology, Volumes I-IV* (D.M. Weir and C. C. Blackwell eds 1986).
- 20 Standard abbreviations for nucleotides and amino acids are used in this specification.

All publications, patents, and patent applications cited herein are incorporated in full by reference. In particular, the contents of UK patent applications 9800760.2, 9819015.0 and 9822143.5 are incorporated herein.

Definitions

- 25 A composition containing X is "substantially free of" Y when at least 85% by weight of the total X+Y in the composition is X. Preferably, X comprises at least about 90% by weight of the total of X+Y in the composition, more preferably at least about 95% or even 99% by weight.

The term "comprising" means "including" as well as "consisting" *eg.* a composition "comprising" X may consist exclusively of X or may include something additional to X, such as X+Y.

The term "heterologous" refers to two biological components that are not found together in nature. The components may be host cells, genes, or regulatory regions, such as promoters. Although the
5 heterologous components are not found together in nature, they can function together, as when a promoter heterologous to a gene is operably linked to the gene. Another example is where a Neisserial sequence is heterologous to a mouse host cell. A further examples would be two epitopes from the same or different proteins which have been assembled in a single protein in an arrangement not found in nature.

- 10 An "origin of replication" is a polynucleotide sequence that initiates and regulates replication of polynucleotides, such as an expression vector. The origin of replication behaves as an autonomous unit of polynucleotide replication within a cell, capable of replication under its own control. An origin of replication may be needed for a vector to replicate in a particular host cell. With certain
15 origins of replication, an expression vector can be reproduced at a high copy number in the presence of the appropriate proteins within the cell. Examples of origins are the autonomously replicating sequences, which are effective in yeast; and the viral T-antigen, effective in COS-7 cells.

- A "mutant" sequence is defined as DNA, RNA or amino acid sequence differing from but having sequence identity with the native or disclosed sequence. Depending on the particular sequence, the
20 degree of sequence identity between the native or disclosed sequence and the mutant sequence is preferably greater than 50% (*eg.* 60%, 70%, 80%, 90%, 95%, 99% or more, calculated using the Smith-Waterman algorithm as described above). As used herein, an "allelic variant" of a nucleic acid molecule, or region, for which nucleic acid sequence is provided herein is a nucleic acid molecule, or region, that occurs essentially at the same locus in the genome of another or second
25 isolate, and that, due to natural variation caused by, for example, mutation or recombination, has a similar but not identical nucleic acid sequence. A coding region allelic variant typically encodes a protein having similar activity to that of the protein encoded by the gene to which it is being compared. An allelic variant can also comprise an alteration in the 5' or 3' untranslated regions of the gene, such as in regulatory control regions (*eg.* see US patent 5,753,235).

Expression systems

The Neisserial nucleotide sequences can be expressed in a variety of different expression systems; for example those used with mammalian cells, baculoviruses, plants, bacteria, and yeast.

i. Mammalian Systems

- 5 Mammalian expression systems are known in the art. A mammalian promoter is any DNA sequence capable of binding mammalian RNA polymerase and initiating the downstream (3') transcription of a coding sequence (eg. structural gene) into mRNA. A promoter will have a transcription initiating region, which is usually placed proximal to the 5' end of the coding sequence, and a TATA box, usually located 25-30 base pairs (bp) upstream of the transcription
- 10 initiation site. The TATA box is thought to direct RNA polymerase II to begin RNA synthesis at the correct site. A mammalian promoter will also contain an upstream promoter element, usually located within 100 to 200 bp upstream of the TATA box. An upstream promoter element determines the rate at which transcription is initiated and can act in either orientation [Sambrook et al. (1989) "Expression of Cloned Genes in Mammalian Cells." In *Molecular Cloning: A*
- 15 *Laboratory Manual*, 2nd ed.].

- Mammalian viral genes are often highly expressed and have a broad host range; therefore sequences encoding mammalian viral genes provide particularly useful promoter sequences. Examples include the SV40 early promoter, mouse mammary tumor virus LTR promoter, adenovirus major late promoter (Ad MLP), and herpes simplex virus promoter. In addition, sequences derived from non-
- 20 viral genes, such as the murine metallothionein gene, also provide useful promoter sequences. Expression may be either constitutive or regulated (inducible), depending on the promoter can be induced with glucocorticoid in hormone-responsive cells.

- The presence of an enhancer element (enhancer), combined with the promoter elements described above, will usually increase expression levels. An enhancer is a regulatory DNA sequence that can
- 25 stimulate transcription up to 1000-fold when linked to homologous or heterologous promoters, with synthesis beginning at the normal RNA start site. Enhancers are also active when they are placed upstream or downstream from the transcription initiation site, in either normal or flipped orientation, or at a distance of more than 1000 nucleotides from the promoter [Maniatis et al. (1987) *Science* 236:1237; Alberts et al. (1989) *Molecular Biology of the Cell*, 2nd ed.]. Enhancer elements
- 30 derived from viruses may be particularly useful, because they usually have a broader host range.

Examples include the SV40 early gene enhancer [Dijkema et al (1985) *EMBO J.* 4:761] and the enhancer/promoters derived from the long terminal repeat (LTR) of the Rous Sarcoma Virus [Gorman et al. (1982b) *Proc. Natl. Acad. Sci.* 79:6777] and from human cytomegalovirus [Boshart et al. (1985) *Cell* 41:521]. Additionally, some enhancers are regulatable and become active only
5 in the presence of an inducer, such as a hormone or metal ion [Sassone-Corsi and Borelli (1986) *Trends Genet.* 2:215; Maniatis et al. (1987) *Science* 236:1237].

A DNA molecule may be expressed intracellularly in mammalian cells. A promoter sequence may be directly linked with the DNA molecule, in which case the first amino acid at the N-terminus of the recombinant protein will always be a methionine, which is encoded by the ATG start codon. If desired,
10 the N-terminus may be cleaved from the protein by *in vitro* incubation with cyanogen bromide.

Alternatively, foreign proteins can also be secreted from the cell into the growth media by creating chimeric DNA molecules that encode a fusion protein comprised of a leader sequence fragment that provides for secretion of the foreign protein in mammalian cells. Preferably, there are processing sites encoded between the leader fragment and the foreign gene that can be cleaved either *in vivo*
15 or *in vitro*. The leader sequence fragment usually encodes a signal peptide comprised of hydrophobic amino acids which direct the secretion of the protein from the cell. The adenovirus tripartite leader is an example of a leader sequence that provides for secretion of a foreign protein in mammalian cells.

Usually, transcription termination and polyadenylation sequences recognized by mammalian cells
20 are regulatory regions located 3' to the translation stop codon and thus, together with the promoter elements, flank the coding sequence. The 3' terminus of the mature mRNA is formed by site-specific post-transcriptional cleavage and polyadenylation [Birnstiel et al. (1985) *Cell* 41:349; Proudfoot and Whitelaw (1988) "Termination and 3' end processing of eukaryotic RNA. In *Transcription and splicing* (ed. B.D. Hames and D.M. Glover); Proudfoot (1989) *Trends Biochem.*
25 *Sci.* 14:105]. These sequences direct the transcription of an mRNA which can be translated into the polypeptide encoded by the DNA. Examples of transcription terminator/polyadenylation signals include those derived from SV40 [Sambrook et al (1989) "Expression of cloned genes in cultured mammalian cells." In *Molecular Cloning: A Laboratory Manual*].

Usually, the above described components, comprising a promoter, polyadenylation signal, and transcription termination sequence are put together into expression constructs. Enhancers, introns with functional splice donor and acceptor sites, and leader sequences may also be included in an expression construct, if desired. Expression constructs are often maintained in a replicon, such as an extrachromosomal element (eg. plasmids) capable of stable maintenance in a host, such as mammalian cells or bacteria. Mammalian replication systems include those derived from animal viruses, which require trans-acting factors to replicate. For example, plasmids containing the replication systems of papovaviruses, such as SV40 [Gluzman (1981) *Cell* 23:175] or polyomavirus, replicate to extremely high copy number in the presence of the appropriate viral T antigen. Additional examples of mammalian replicons include those derived from bovine papillomavirus and Epstein-Barr virus. Additionally, the replicon may have two replicaton systems, thus allowing it to be maintained, for example, in mammalian cells for expression and in a prokaryotic host for cloning and amplification. Examples of such mammalian-bacteria shuttle vectors include pMT2 [Kaufman et al. (1989) *Mol. Cell. Biol.* 9:946] and pHEBO [Shimizu et al. (1986) *Mol. Cell. Biol.* 6:1074].

The transformation procedure used depends upon the host to be transformed. Methods for introduction of heterologous polynucleotides into mammalian cells are known in the art and include dextran-mediated transfection, calcium phosphate precipitation, polybrene mediated transfection, protoplast fusion, electroporation, encapsulation of the polynucleotide(s) in liposomes, and direct microinjection of the DNA into nuclei.

Mammalian cell lines available as hosts for expression are known in the art and include many immortalized cell lines available from the American Type Culture Collection (ATCC), including but not limited to, Chinese hamster ovary (CHO) cells, HeLa cells, baby hamster kidney (BHK) cells, monkey kidney cells (COS), human hepatocellular carcinoma cells (eg. Hep G2), and a number of other cell lines.

ii. Baculovirus Systems

The polynucleotide encoding the protein can also be inserted into a suitable insect expression vector, and is operably linked to the control elements within that vector. Vector construction employs techniques which are known in the art. Generally, the components of the expression system include a transfer vector, usually a bacterial plasmid, which contains both a fragment of the baculovirus

genome, and a convenient restriction site for insertion of the heterologous gene or genes to be expressed; a wild type baculovirus with a sequence homologous to the baculovirus-specific fragment in the transfer vector (this allows for the homologous recombination of the heterologous gene in to the baculovirus genome); and appropriate insect host cells and growth media.

- 5 After inserting the DNA sequence encoding the protein into the transfer vector, the vector and the wild type viral genome are transfected into an insect host cell where the vector and viral genome are allowed to recombine. The packaged recombinant virus is expressed and recombinant plaques are identified and purified. Materials and methods for baculovirus/insect cell expression systems are commercially available in kit form from, *inter alia*, Invitrogen, San Diego CA ("MaxBac" kit).
- 10 These techniques are generally known to those skilled in the art and fully described in Summers and Smith, *Texas Agricultural Experiment Station Bulletin No. 1555* (1987) (hereinafter "Summers and Smith").

- Prior to inserting the DNA sequence encoding the protein into the baculovirus genome, the above described components, comprising a promoter, leader (if desired), coding sequence of interest, and
- 15 transcription termination sequence, are usually assembled into an intermediate transplacement construct (transfer vector). This construct may contain a single gene and operably linked regulatory elements; multiple genes, each with its own set of operably linked regulatory elements; or multiple genes, regulated by the same set of regulatory elements. Intermediate transplacement constructs are often maintained in a replicon, such as an extrachromosomal element (eg. plasmids) capable of stable
- 20 maintenance in a host, such as a bacterium. The replicon will have a replication system, thus allowing it to be maintained in a suitable host for cloning and amplification.

- Currently, the most commonly used transfer vector for introducing foreign genes into AcNPV is pAc373. Many other vectors, known to those of skill in the art, have also been designed. These include, for example, pVL985 (which alters the polyhedrin start codon from ATG to ATT, and
- 25 which introduces a BamHI cloning site 32 basepairs downstream from the ATT; see Luckow and Summers, *Virology* (1989) 17:31.

The plasmid usually also contains the polyhedrin polyadenylation signal (Miller et al. (1988) *Ann. Rev. Microbiol.*, 42:177) and a prokaryotic ampicillin-resistance (*amp*) gene and origin of replication for selection and propagation in *E. coli*.

Baculovirus transfer vectors usually contain a baculovirus promoter. A baculovirus promoter is any DNA sequence capable of binding a baculovirus RNA polymerase and initiating the downstream (5' to 3') transcription of a coding sequence (eg. structural gene) into mRNA. A promoter will have a transcription initiation region which is usually placed proximal to the 5' end of the coding sequence. This transcription initiation region usually includes an RNA polymerase binding site and a transcription initiation site. A baculovirus transfer vector may also have a second domain called an enhancer, which, if present, is usually distal to the structural gene. Expression may be either regulated or constitutive.

Structural genes, abundantly transcribed at late times in a viral infection cycle, provide particularly useful promoter sequences. Examples include sequences derived from the gene encoding the viral polyhedron protein, Friesen et al., (1986) "The Regulation of Baculovirus Gene Expression," in: *The Molecular Biology of Baculoviruses* (ed. Walter Doerfler); EPO Publ. Nos. 127 839 and 155 476; and the gene encoding the p10 protein, Vlak et al., (1988), *J. Gen. Virol.* 69:765.

DNA encoding suitable signal sequences can be derived from genes for secreted insect or baculovirus proteins, such as the baculovirus polyhedrin gene (Carbonell et al. (1988) *Gene*, 73:409). Alternatively, since the signals for mammalian cell posttranslational modifications (such as signal peptide cleavage, proteolytic cleavage, and phosphorylation) appear to be recognized by insect cells, and the signals required for secretion and nuclear accumulation also appear to be conserved between the invertebrate cells and vertebrate cells, leaders of non-insect origin, such as those derived from genes encoding human α -interferon, Maeda et al., (1985), *Nature* 315:592; human gastrin-releasing peptide, Lebacqz-Verheyden et al., (1988), *Molec. Cell. Biol.* 8:3129; human IL-2, Smith et al., (1985) *Proc. Nat'l Acad. Sci. USA*, 82:8404; mouse IL-3, (Miyajima et al., (1987) *Gene* 58:273; and human glucocerebrosidase, Martin et al. (1988) *DNA*, 7:99, can also be used to provide for secretion in insects.

A recombinant polypeptide or polyprotein may be expressed intracellularly or, if it is expressed with the proper regulatory sequences, it can be secreted. Good intracellular expression of nonfused foreign proteins usually requires heterologous genes that ideally have a short leader sequence containing suitable translation initiation signals preceding an ATG start signal. If desired, methionine at the N-terminus may be cleaved from the mature protein by *in vitro* incubation with cyanogen bromide.

Alternatively, recombinant polyproteins or proteins which are not naturally secreted can be secreted from the insect cell by creating chimeric DNA molecules that encode a fusion protein comprised of a leader sequence fragment that provides for secretion of the foreign protein in insects. The leader sequence fragment usually encodes a signal peptide comprised of hydrophobic amino acids which direct the translocation of the protein into the endoplasmic reticulum.

After insertion of the DNA sequence and/or the gene encoding the expression product precursor of the protein, an insect cell host is co-transformed with the heterologous DNA of the transfer vector and the genomic DNA of wild type baculovirus – usually by co-transfection. The promoter and transcription termination sequence of the construct will usually comprise a 2-5kb section of the baculovirus genome. Methods for introducing heterologous DNA into the desired site in the baculovirus virus are known in the art. (See Summers and Smith *supra*; Ju et al. (1987); Smith et al., *Mol. Cell. Biol.* (1983) 3:2156; and Luckow and Summers (1989)). For example, the insertion can be into a gene such as the polyhedrin gene, by homologous double crossover recombination; insertion can also be into a restriction enzyme site engineered into the desired baculovirus gene. Miller et al., (1989), *Bioessays* 4:91. The DNA sequence, when cloned in place of the polyhedrin gene in the expression vector, is flanked both 5' and 3' by polyhedrin-specific sequences and is positioned downstream of the polyhedrin promoter.

The newly formed baculovirus expression vector is subsequently packaged into an infectious recombinant baculovirus. Homologous recombination occurs at low frequency (between about 1% and about 5%); thus, the majority of the virus produced after cotransfection is still wild-type virus. Therefore, a method is necessary to identify recombinant viruses. An advantage of the expression system is a visual screen allowing recombinant viruses to be distinguished. The polyhedrin protein, which is produced by the native virus, is produced at very high levels in the nuclei of infected cells at late times after viral infection. Accumulated polyhedrin protein forms occlusion bodies that also contain embedded particles. These occlusion bodies, up to 15 μm in size, are highly refractile, giving them a bright shiny appearance that is readily visualized under the light microscope. Cells infected with recombinant viruses lack occlusion bodies. To distinguish recombinant virus from wild-type virus, the transfection supernatant is plaqued onto a monolayer of insect cells by techniques known to those skilled in the art. Namely, the plaques are screened under the light microscope for the presence (indicative of wild-type virus) or absence (indicative of recombinant

virus) of occlusion bodies. "Current Protocols in Microbiology" Vol. 2 (Ausubel et al. eds) at 16.8 (Supp. 10, 1990); Summers and Smith, *supra*; Miller et al. (1989).

Recombinant baculovirus expression vectors have been developed for infection into several insect cells. For example, recombinant baculoviruses have been developed for, *inter alia*: *Aedes aegypti*,
5 , *Autographa californica*, *Bombyx mori*, *Drosophila melanogaster*, *Spodoptera frugiperda*, and *Trichoplusia ni* (WO 89/046699; Carbonell et al., (1985) *J. Virol.* 56:153; Wright (1986) *Nature* 321:718; Smith et al., (1983) *Mol. Cell. Biol.* 3:2156; and see generally, Fraser, *et al.* (1989) *In Vitro Cell. Dev. Biol.* 25:225).

Cells and cell culture media are commercially available for both direct and fusion expression of
10 heterologous polypeptides in a baculovirus/expression system; cell culture technology is generally known to those skilled in the art. See, eg. Summers and Smith *supra*.

The modified insect cells may then be grown in an appropriate nutrient medium, which allows for stable maintenance of the plasmid(s) present in the modified insect host. Where the expression product gene is under inducible control, the host may be grown to high density, and expression induced.
15 Alternatively, where expression is constitutive, the product will be continuously expressed into the medium and the nutrient medium must be continuously circulated, while removing the product of interest and augmenting depleted nutrients. The product may be purified by such techniques as chromatography, eg. HPLC, affinity chromatography, ion exchange chromatography, etc.; electrophoresis; density gradient centrifugation; solvent extraction, or the like. As appropriate, the
20 product may be further purified, as required, so as to remove substantially any insect proteins which are also secreted in the medium or result from lysis of insect cells, so as to provide a product which is at least substantially free of host debris, eg. proteins, lipids and polysaccharides.

In order to obtain protein expression, recombinant host cells derived from the transformants are incubated under conditions which allow expression of the recombinant protein encoding sequence.
25 These conditions will vary, dependent upon the host cell selected. However, the conditions are readily ascertainable to those of ordinary skill in the art, based upon what is known in the art.

iii. Plant Systems

There are many plant cell culture and whole plant genetic expression systems known in the art. Exemplary plant cellular genetic expression systems include those described in patents, such as:

US 5,693,506; US 5,659,122; and US 5,608,143. Additional examples of genetic expression in plant cell culture has been described by Zenk, *Phytochemistry* 30:3861-3863 (1991). Descriptions of plant protein signal peptides may be found in addition to the references described above in Vaulcombe et al., *Mol. Gen. Genet.* 209:33-40 (1987); Chandler et al., *Plant Molecular Biology* 3:407-418 (1984); Rogers, *J. Biol. Chem.* 260:3731-3738 (1985); Rothstein et al., *Gene* 55:353-356 (1987); Whittier et al., *Nucleic Acids Research* 15:2515-2535 (1987); Wirsal et al., *Molecular Microbiology* 3:3-14 (1989); Yu et al., *Gene* 122:247-253 (1992). A description of the regulation of plant gene expression by the phytohormone, gibberellic acid and secreted enzymes induced by gibberellic acid can be found in R.L. Jones and J. MacMillin, Gibberellins: in: *Advanced Plant Physiology*, Malcolm B. Wilkins, ed., 1984 Pitman Publishing Limited, London, pp. 21-52. References that describe other metabolically-regulated genes: Sheen, *Plant Cell*, 2:1027-1038(1990); Maas et al., *EMBO J.* 9:3447-3452 (1990); Benkel and Hickey, *Proc. Natl. Acad. Sci.* 84:1337-1339 (1987)

Typically, using techniques known in the art, a desired polynucleotide sequence is inserted into an expression cassette comprising genetic regulatory elements designed for operation in plants. The expression cassette is inserted into a desired expression vector with companion sequences upstream and downstream from the expression cassette suitable for expression in a plant host. The companion sequences will be of plasmid or viral origin and provide necessary characteristics to the vector to permit the vectors to move DNA from an original cloning host, such as bacteria, to the desired plant host. The basic bacterial/plant vector construct will preferably provide a broad host range prokaryote replication origin; a prokaryote selectable marker; and, for *Agrobacterium* transformations, T DNA sequences for *Agrobacterium*-mediated transfer to plant chromosomes. Where the heterologous gene is not readily amenable to detection, the construct will preferably also have a selectable marker gene suitable for determining if a plant cell has been transformed. A general review of suitable markers, for example for the members of the grass family, is found in Wilmink and Dons, 1993, *Plant Mol. Biol. Rept.*, 11(2):165-185.

Sequences suitable for permitting integration of the heterologous sequence into the plant genome are also recommended. These might include transposon sequences and the like for homologous recombination as well as Ti sequences which permit random insertion of a heterologous expression cassette into a plant genome. Suitable prokaryote selectable markers include resistance toward

antibiotics such as ampicillin or tetracycline. Other DNA sequences encoding additional functions may also be present in the vector, as is known in the art.

- The nucleic acid molecules of the subject invention may be included into an expression cassette for expression of the protein(s) of interest. Usually, there will be only one expression cassette, although two or more are feasible. The recombinant expression cassette will contain in addition to the heterologous protein encoding sequence the following elements, a promoter region, plant 5' untranslated sequences, initiation codon depending upon whether or not the structural gene comes equipped with one, and a transcription and translation termination sequence. Unique restriction enzyme sites at the 5' and 3' ends of the cassette allow for easy insertion into a pre-existing vector.
- 10 A heterologous coding sequence may be for any protein relating to the present invention. The sequence encoding the protein of interest will encode a signal peptide which allows processing and translocation of the protein, as appropriate, and will usually lack any sequence which might result in the binding of the desired protein of the invention to a membrane. Since, for the most part, the transcriptional initiation region will be for a gene which is expressed and translocated during
- 15 germination, by employing the signal peptide which provides for translocation, one may also provide for translocation of the protein of interest. In this way, the protein(s) of interest will be translocated from the cells in which they are expressed and may be efficiently harvested. Typically secretion in seeds are across the aleurone or scutellar epithelium layer into the endosperm of the seed. While it is not required that the protein be secreted from the cells in which the protein is
- 20 produced, this facilitates the isolation and purification of the recombinant protein.

Since the ultimate expression of the desired gene product will be in a eucaryotic cell it is desirable to determine whether any portion of the cloned gene contains sequences which will be processed out as introns by the host's splicosome machinery. If so, site-directed mutagenesis of the "intron" region may be conducted to prevent losing a portion of the genetic message as a false intron code,

25 Reed and Maniatis, *Cell* 41:95-105, 1985.

The vector can be microinjected directly into plant cells by use of micropipettes to mechanically transfer the recombinant DNA. Crossway, *Mol. Gen. Genet*, 202:179-185, 1985. The genetic material may also be transferred into the plant cell by using polyethylene glycol, Krens, et al., *Nature*, 296, 72-74, 1982. Another method of introduction of nucleic acid segments is high

velocity ballistic penetration by small particles with the nucleic acid either within the matrix of small beads or particles, or on the surface, Klein, et al., *Nature*, 327, 70-73, 1987 and Knudsen and Muller, 1991, *Planta*, 185:330-336 teaching particle bombardment of barley endosperm to create transgenic barley. Yet another method of introduction would be fusion of protoplasts with other
5 entities, either minicells, cells, lysosomes or other fusible lipid-surfaced bodies, Fraley, et al., *Proc. Natl. Acad. Sci. USA*, 79, 1859-1863, 1982.

The vector may also be introduced into the plant cells by electroporation. (Fromm et al., *Proc. Natl. Acad. Sci. USA* 82:5824, 1985). In this technique, plant protoplasts are electroporated in the presence of plasmids containing the gene construct. Electrical impulses of high field strength
10 reversibly permeabilize biomembranes allowing the introduction of the plasmids. Electroporated plant protoplasts reform the cell wall, divide, and form plant callus.

All plants from which protoplasts can be isolated and cultured to give whole regenerated plants can be transformed by the present invention so that whole plants are recovered which contain the transferred gene. It is known that practically all plants can be regenerated from cultured cells or
15 tissues, including but not limited to all major species of sugarcane, sugar beet, cotton, fruit and other trees, legumes and vegetables. Some suitable plants include, for example, species from the genera *Fragaria*, *Lotus*, *Medicago*, *Onobrychis*, *Trifolium*, *Trigonella*, *Vigna*, *Citrus*, *Linum*, *Geranium*, *Manihot*, *Daucus*, *Arabidopsis*, *Brassica*, *Raphanus*, *Sinapis*, *Atropa*, *Capsicum*, *Datura*, *Hyoscyamus*, *Lycopersion*, *Nicotiana*, *Solanum*, *Petunia*, *Digitalis*, *Majorana*, *Cichorium*,
20 *Helianthus*, *Lactuca*, *Bromus*, *Asparagus*, *Antirrhinum*, *Hererocallis*, *Nemesia*, *Pelargonium*, *Panicum*, *Pennisetum*, *Ranunculus*, *Senecio*, *Salpiglossis*, *Cucumis*, *Browaalia*, *Glycine*, *Lolium*, *Zea*, *Triticum*, *Sorghum*, and *Datura*.

Means for regeneration vary from species to species of plants, but generally a suspension of transformed protoplasts containing copies of the heterologous gene is first provided. Callus tissue
25 is formed and shoots may be induced from callus and subsequently rooted. Alternatively, embryo formation can be induced from the protoplast suspension. These embryos germinate as natural embryos to form plants. The culture media will generally contain various amino acids and hormones, such as auxin and cytokinins. It is also advantageous to add glutamic acid and proline to the medium, especially for such species as corn and alfalfa. Shoots and roots normally develop
30 simultaneously. Efficient regeneration will depend on the medium, on the genotype, and on the

history of the culture. If these three variables are controlled, then regeneration is fully reproducible and repeatable.

In some plant cell culture systems, the desired protein of the invention may be excreted or alternatively, the protein may be extracted from the whole plant. Where the desired protein of the invention is secreted into the medium, it may be collected. Alternatively, the embryos and embryoless-half seeds or other plant tissue may be mechanically disrupted to release any secreted protein between cells and tissues. The mixture may be suspended in a buffer solution to retrieve soluble proteins. Conventional protein isolation and purification methods will be then used to purify the recombinant protein. Parameters of time, temperature pH, oxygen, and volumes will be adjusted through routine methods to optimize expression and recovery of heterologous protein.

iv. Bacterial Systems

Bacterial expression techniques are known in the art. A bacterial promoter is any DNA sequence capable of binding bacterial RNA polymerase and initiating the downstream (3') transcription of a coding sequence (*eg.* structural gene) into mRNA. A promoter will have a transcription initiation region which is usually placed proximal to the 5' end of the coding sequence. This transcription initiation region usually includes an RNA polymerase binding site and a transcription initiation site. A bacterial promoter may also have a second domain called an operator, that may overlap an adjacent RNA polymerase binding site at which RNA synthesis begins. The operator permits negative regulated (inducible) transcription, as a gene repressor protein may bind the operator and thereby inhibit transcription of a specific gene. Constitutive expression may occur in the absence of negative regulatory elements, such as the operator. In addition, positive regulation may be achieved by a gene activator protein binding sequence, which, if present is usually proximal (5') to the RNA polymerase binding sequence. An example of a gene activator protein is the catabolite activator protein (CAP), which helps initiate transcription of the lac operon in *Escherichia coli* (*E. coli*) [Raibaud *et al.* (1984) *Annu. Rev. Genet.* 18:173]. Regulated expression may therefore be either positive or negative, thereby either enhancing or reducing transcription.

Sequences encoding metabolic pathway enzymes provide particularly useful promoter sequences. Examples include promoter sequences derived from sugar metabolizing enzymes, such as galactose, lactose (*lac*) [Chang *et al.* (1977) *Nature* 198:1056], and maltose. Additional examples include promoter sequences derived from biosynthetic enzymes such as tryptophan (*trp*) [Goeddel *et al.*

(1980) *Nuc. Acids Res.* 8:4057; Yelverton *et al.* (1981) *Nucl. Acids Res.* 9:731; US patent 4,738,921; EP-A-0036776 and EP-A-0121775]. The g-lactamase (*bla*) promoter system [Weissmann (1981) "The cloning of interferon and other mistakes." In *Interferon 3* (ed. I. Gresser)], bacteriophage lambda PL [Shimatake *et al.* (1981) *Nature* 292:128] and T5 [US patent 4,689,406]
5 promoter systems also provide useful promoter sequences.

In addition, synthetic promoters which do not occur in nature also function as bacterial promoters. For example, transcription activation sequences of one bacterial or bacteriophage promoter may be joined with the operon sequences of another bacterial or bacteriophage promoter, creating a synthetic hybrid promoter [US patent 4,551,433]. For example, the *tac* promoter is a hybrid *trp-lac*
10 promoter comprised of both *trp* promoter and *lac* operon sequences that is regulated by the *lac* repressor [Amann *et al.* (1983) *Gene* 25:167; de Boer *et al.* (1983) *Proc. Natl. Acad. Sci.* 80:21]. Furthermore, a bacterial promoter can include naturally occurring promoters of non-bacterial origin that have the ability to bind bacterial RNA polymerase and initiate transcription. A naturally occurring promoter of non-bacterial origin can also be coupled with a compatible RNA polymerase
15 to produce high levels of expression of some genes in prokaryotes. The bacteriophage T7 RNA polymerase/promoter system is an example of a coupled promoter system [Studier *et al.* (1986) *J. Mol. Biol.* 189:113; Tabor *et al.* (1985) *Proc Natl. Acad. Sci.* 82:1074]. In addition, a hybrid promoter can also be comprised of a bacteriophage promoter and an *E. coli* operator region (EPO-A-0 267 851).

20 In addition to a functioning promoter sequence, an efficient ribosome binding site is also useful for the expression of foreign genes in prokaryotes. In *E. coli*, the ribosome binding site is called the Shine-Dalgarno (SD) sequence and includes an initiation codon (ATG) and a sequence 3-9 nucleotides in length located 3-11 nucleotides upstream of the initiation codon [Shine *et al.* (1975) *Nature* 254:34]. The SD sequence is thought to promote binding of mRNA to the ribosome by the
25 pairing of bases between the SD sequence and the 3' end of *E. coli* 16S rRNA [Steitz *et al.* (1979) "Genetic signals and nucleotide sequences in messenger RNA." In *Biological Regulation and Development: Gene Expression* (ed. R.F. Goldberger)]. To express eukaryotic genes and prokaryotic genes with weak ribosome-binding site [Sambrook *et al.* (1989) "Expression of cloned genes in Escherichia coli." In *Molecular Cloning: A Laboratory Manual*].

A DNA molecule may be expressed intracellularly. A promoter sequence may be directly linked with the DNA molecule, in which case the first amino acid at the N-terminus will always be a methionine, which is encoded by the ATG start codon. If desired, methionine at the N-terminus may be cleaved from the protein by *in vitro* incubation with cyanogen bromide or by either *in vivo* on *in vitro* incubation with a bacterial methionine N-terminal peptidase (EPO-A-0 219 237).

Fusion proteins provide an alternative to direct expression. Usually, a DNA sequence encoding the N-terminal portion of an endogenous bacterial protein, or other stable protein, is fused to the 5' end of heterologous coding sequences. Upon expression, this construct will provide a fusion of the two amino acid sequences. For example, the bacteriophage lambda cell gene can be linked at the 5' terminus of a foreign gene and expressed in bacteria. The resulting fusion protein preferably retains a site for a processing enzyme (factor Xa) to cleave the bacteriophage protein from the foreign gene [Nagai *et al.* (1984) *Nature* 309:810]. Fusion proteins can also be made with sequences from the *lacZ* [Jia *et al.* (1987) *Gene* 60:197], *trpE* [Allen *et al.* (1987) *J. Biotechnol.* 5:93; Makoff *et al.* (1989) *J. Gen. Microbiol.* 135:11], and *Chey* [EP-A-0 324 647] genes. The DNA sequence at the junction of the two amino acid sequences may or may not encode a cleavable site. Another example is a ubiquitin fusion protein. Such a fusion protein is made with the ubiquitin region that preferably retains a site for a processing enzyme (*eg.* ubiquitin specific processing-protease) to cleave the ubiquitin from the foreign protein. Through this method, native foreign protein can be isolated [Miller *et al.* (1989) *Bio/Technology* 7:698].

Alternatively, foreign proteins can also be secreted from the cell by creating chimeric DNA molecules that encode a fusion protein comprised of a signal peptide sequence fragment that provides for secretion of the foreign protein in bacteria [US patent 4,336,336]. The signal sequence fragment usually encodes a signal peptide comprised of hydrophobic amino acids which direct the secretion of the protein from the cell. The protein is either secreted into the growth media (gram-positive bacteria) or into the periplasmic space, located between the inner and outer membrane of the cell (gram-negative bacteria). Preferably there are processing sites, which can be cleaved either *in vivo* or *in vitro* encoded between the signal peptide fragment and the foreign gene.

DNA encoding suitable signal sequences can be derived from genes for secreted bacterial proteins, such as the *E. coli* outer membrane protein gene (*ompA*) [Masui *et al.* (1983), in: *Experimental Manipulation of Gene Expression*; Ghayeb *et al.* (1984) *EMBO J.* 3:2437] and the *E. coli* alkaline

phosphatase signal sequence (*phoA*) [Oka *et al.* (1985) *Proc. Natl. Acad. Sci.* 82:7212]. As an additional example, the signal sequence of the alpha-amylase gene from various *Bacillus* strains can be used to secrete heterologous proteins from *B. subtilis* [Palva *et al.* (1982) *Proc. Natl. Acad. Sci. USA* 79:5582; EP-A-0 244 042].

- 5 Usually, transcription termination sequences recognized by bacteria are regulatory regions located 3' to the translation stop codon, and thus together with the promoter flank the coding sequence. These sequences direct the transcription of an mRNA which can be translated into the polypeptide encoded by the DNA. Transcription termination sequences frequently include DNA sequences of about 50 nucleotides capable of forming stem loop structures that aid in terminating transcription.
- 10 Examples include transcription termination sequences derived from genes with strong promoters, such as the *trp* gene in *E. coli* as well as other biosynthetic genes.

Usually, the above described components, comprising a promoter, signal sequence (if desired), coding sequence of interest, and transcription termination sequence, are put together into expression constructs. Expression constructs are often maintained in a replicon, such as an extrachromosomal

15 element (*eg.* plasmids) capable of stable maintenance in a host, such as bacteria. The replicon will have a replication system, thus allowing it to be maintained in a prokaryotic host either for expression or for cloning and amplification. In addition, a replicon may be either a high or low copy number plasmid. A high copy number plasmid will generally have a copy number ranging from about 5 to about 200, and usually about 10 to about 150. A host containing a high copy

20 number plasmid will preferably contain at least about 10, and more preferably at least about 20 plasmids. Either a high or low copy number vector may be selected, depending upon the effect of the vector and the foreign protein on the host.

Alternatively, the expression constructs can be integrated into the bacterial genome with an integrating vector. Integrating vectors usually contain at least one sequence homologous to the

25 bacterial chromosome that allows the vector to integrate. Integrations appear to result from recombinations between homologous DNA in the vector and the bacterial chromosome. For example, integrating vectors constructed with DNA from various *Bacillus* strains integrate into the *Bacillus* chromosome (EP-A- 0 127 328). Integrating vectors may also be comprised of bacteriophage or transposon sequences.

Usually, extrachromosomal and integrating expression constructs may contain selectable markers to allow for the selection of bacterial strains that have been transformed. Selectable markers can be expressed in the bacterial host and may include genes which render bacteria resistant to drugs such as ampicillin, chloramphenicol, erythromycin, kanamycin (neomycin), and tetracycline
5 [Davies *et al.* (1978) *Annu. Rev. Microbiol.* 32:469]. Selectable markers may also include biosynthetic genes, such as those in the histidine, tryptophan, and leucine biosynthetic pathways.

Alternatively, some of the above described components can be put together in transformation vectors. Transformation vectors are usually comprised of a selectable market that is either maintained in a replicon or developed into an integrating vector, as described above.

10 Expression and transformation vectors, either extra-chromosomal replicons or integrating vectors, have been developed for transformation into many bacteria. For example, expression vectors have been developed for, *inter alia*, the following bacteria: *Bacillus subtilis* [Palva *et al.* (1982) *Proc. Natl. Acad. Sci. USA* 79:5582; EP-A-0 036 259 and EP-A-0 063 953; WO 84/04541], *Escherichia coli* [Shimatake *et al.* (1981) *Nature* 292:128; Amann *et al.* (1985) *Gene* 40:183; Studier *et al.*
15 (1986) *J. Mol. Biol.* 189:113; EP-A-0 036 776, EP-A-0 136 829 and EP-A-0 136 907], *Streptococcus cremoris* [Powell *et al.* (1988) *Appl. Environ. Microbiol.* 54:655]; *Streptococcus lividans* [Powell *et al.* (1988) *Appl. Environ. Microbiol.* 54:655], *Streptomyces lividans* [US patent 4,745,056].

Methods of introducing exogenous DNA into bacterial hosts are well-known in the art, and usually
20 include either the transformation of bacteria treated with CaCl_2 or other agents, such as divalent cations and DMSO. DNA can also be introduced into bacterial cells by electroporation. Transformation procedures usually vary with the bacterial species to be transformed. See *eg.* [Masson *et al.* (1989) *FEMS Microbiol. Lett.* 60:273; Palva *et al.* (1982) *Proc. Natl. Acad. Sci. USA* 79:5582; EP-A-0 036 259 and EP-A-0 063 953; WO 84/04541, *Bacillus*], [Miller *et al.* (1988)
25 *Proc. Natl. Acad. Sci.* 85:856; Wang *et al.* (1990) *J. Bacteriol.* 172:949, *Campylobacter*], [Cohen *et al.* (1973) *Proc. Natl. Acad. Sci.* 69:2110; Dower *et al.* (1988) *Nucleic Acids Res.* 16:6127; Kushner (1978) "An improved method for transformation of *Escherichia coli* with ColE1-derived plasmids. In *Genetic Engineering: Proceedings of the International Symposium on Genetic Engineering* (eds. H.W. Boyer and S. Nicosia); Mandel *et al.* (1970) *J. Mol. Biol.* 53:159; Taketo
30 (1988) *Biochim. Biophys. Acta* 949:318; *Escherichia*], [Chassy *et al.* (1987) *FEMS Microbiol. Lett.*

- 44:173 *Lactobacillus*]; [Fiedler *et al.* (1988) *Anal. Biochem* 170:38, *Pseudomonas*]; [Augustin *et al.* (1990) *FEMS Microbiol. Lett.* 66:203, *Staphylococcus*], [Barany *et al.* (1980) *J. Bacteriol.* 144:698; Harlander (1987) "Transformation of *Streptococcus lactis* by electroporation, in: *Streptococcal Genetics* (ed. J. Ferretti and R. Curtiss III); Perry *et al.* (1981) *Infect. Immun.* 32:1295; Powell *et al.* (1988) *Appl. Environ. Microbiol.* 54:655; Somkuti *et al.* (1987) *Proc. 4th Evr. Cong. Biotechnology* 1:412, *Streptococcus*].

v. Yeast Expression

- Yeast expression systems are also known to one of ordinary skill in the art. A yeast promoter is any DNA sequence capable of binding yeast RNA polymerase and initiating the downstream (3') transcription of a coding sequence (eg. structural gene) into mRNA. A promoter will have a transcription initiation region which is usually placed proximal to the 5' end of the coding sequence. This transcription initiation region usually includes an RNA polymerase binding site (the "TATA Box") and a transcription initiation site. A yeast promoter may also have a second domain called an upstream activator sequence (UAS), which, if present, is usually distal to the structural gene.
- 15 The UAS permits regulated (inducible) expression. Constitutive expression occurs in the absence of a UAS. Regulated expression may be either positive or negative, thereby either enhancing or reducing transcription.

- Yeast is a fermenting organism with an active metabolic pathway, therefore sequences encoding enzymes in the metabolic pathway provide particularly useful promoter sequences. Examples include alcohol dehydrogenase (ADH) (EP-A-0 284 044), enolase, glucokinase, glucose-6-phosphate isomerase, glyceraldehyde-3-phosphate-dehydrogenase (GAP or GAPDH), hexokinase, phosphofructokinase, 3-phosphoglycerate mutase, and pyruvate kinase (PyK) (EPO-A-0 329 203). The yeast *PHO5* gene, encoding acid phosphatase, also provides useful promoter sequences [Myanohara *et al.* (1983) *Proc. Natl. Acad. Sci. USA* 80:1].

- 25 In addition, synthetic promoters which do not occur in nature also function as yeast promoters. For example, UAS sequences of one yeast promoter may be joined with the transcription activation region of another yeast promoter, creating a synthetic hybrid promoter. Examples of such hybrid promoters include the ADH regulatory sequence linked to the GAP transcription activation region (US Patent Nos. 4,876,197 and 4,880,734). Other examples of hybrid promoters include promoters
- 30 which consist of the regulatory sequences of either the *ADH2*, *GAL4*, *GAL10*, OR *PHO5* genes,

- combined with the transcriptional activation region of a glycolytic enzyme gene such as GAP or PyK (EP-A-0 164 556). Furthermore, a yeast promoter can include naturally occurring promoters of non-yeast origin that have the ability to bind yeast RNA polymerase and initiate transcription. Examples of such promoters include, *inter alia*, [Cohen *et al.* (1980) *Proc. Natl. Acad. Sci. USA* 77:1078; Henikoff *et al.* (1981) *Nature* 283:835; Hollenberg *et al.* (1981) *Curr. Topics Microbiol. Immunol.* 96:119; Hollenberg *et al.* (1979) "The Expression of Bacterial Antibiotic Resistance Genes in the Yeast *Saccharomyces cerevisiae*," in: *Plasmids of Medical, Environmental and Commercial Importance* (eds. K.N. Timmis and A. Puhler); Mercerau-Puigalon *et al.* (1980) *Gene* 11:163; Panthier *et al.* (1980) *Curr. Genet.* 2:109;].
- 5
- 10 A DNA molecule may be expressed intracellularly in yeast. A promoter sequence may be directly linked with the DNA molecule, in which case the first amino acid at the N-terminus of the recombinant protein will always be a methionine, which is encoded by the ATG start codon. If desired, methionine at the N-terminus may be cleaved from the protein by *in vitro* incubation with cyanogen bromide.
- 15 Fusion proteins provide an alternative for yeast expression systems, as well as in mammalian, baculovirus, and bacterial expression systems. Usually, a DNA sequence encoding the N-terminal portion of an endogenous yeast protein, or other stable protein, is fused to the 5' end of heterologous coding sequences. Upon expression, this construct will provide a fusion of the two amino acid sequences. For example, the yeast or human superoxide dismutase (SOD) gene, can be
- 20 linked at the 5' terminus of a foreign gene and expressed in yeast. The DNA sequence at the junction of the two amino acid sequences may or may not encode a cleavable site. See *eg.* EP-A-0 196 056. Another example is a ubiquitin fusion protein. Such a fusion protein is made with the ubiquitin region that preferably retains a site for a processing enzyme (*eg.* ubiquitin-specific processing protease) to cleave the ubiquitin from the foreign protein. Through this method,
- 25 therefore, native foreign protein can be isolated (*eg.* WO88/024066).

Alternatively, foreign proteins can also be secreted from the cell into the growth media by creating chimeric DNA molecules that encode a fusion protein comprised of a leader sequence fragment that provide for secretion in yeast of the foreign protein. Preferably, there are processing sites encoded between the leader fragment and the foreign gene that can be cleaved either *in vivo* or *in vitro*. The

leader sequence fragment usually encodes a signal peptide comprised of hydrophobic amino acids which direct the secretion of the protein from the cell.

DNA encoding suitable signal sequences can be derived from genes for secreted yeast proteins, such as the yeast invertase gene (EP-A-0 012 873; JPO. 62,096,086) and the A-factor gene (US
5 patent 4,588,684). Alternatively, leaders of non-yeast origin, such as an interferon leader, exist that also provide for secretion in yeast (EP-A-0 060 057).

A preferred class of secretion leaders are those that employ a fragment of the yeast alpha-factor gene, which contains both a "pre" signal sequence, and a "pro" region. The types of alpha-factor fragments that can be employed include the full-length pre-pro alpha factor leader (about 83 amino
10 acid residues) as well as truncated alpha-factor leaders (usually about 25 to about 50 amino acid residues) (US Patents 4,546,083 and 4,870,008; EP-A-0 324 274). Additional leaders employing an alpha-factor leader fragment that provides for secretion include hybrid alpha-factor leaders made with a presequence of a first yeast, but a pro-region from a second yeast alphafactor. (eg. see WO 89/02463.)

15 Usually, transcription termination sequences recognized by yeast are regulatory regions located 3' to the translation stop codon, and thus together with the promoter flank the coding sequence. These sequences direct the transcription of an mRNA which can be translated into the polypeptide encoded by the DNA. Examples of transcription terminator sequence and other yeast-recognized termination sequences, such as those coding for glycolytic enzymes.

20 Usually, the above described components, comprising a promoter, leader (if desired), coding sequence of interest, and transcription termination sequence, are put together into expression constructs. Expression constructs are often maintained in a replicon, such as an extrachromosomal element (eg. plasmids) capable of stable maintenance in a host, such as yeast or bacteria. The replicon may have two replication systems, thus allowing it to be maintained, for example, in yeast
25 for expression and in a prokaryotic host for cloning and amplification. Examples of such yeast-bacteria shuttle vectors include YEp24 [Botstein *et al.* (1979) *Gene* 8:17-24], pCI/1 [Brake *et al.* (1984) *Proc. Natl. Acad. Sci USA* 81:4642-4646], and YRp17 [Stinchcomb *et al.* (1982) *J. Mol. Biol.* 158:157]. In addition, a replicon may be either a high or low copy number plasmid. A high copy number plasmid will generally have a copy number ranging from about 5 to about 200, and

usually about 10 to about 150. A host containing a high copy number plasmid will preferably have at least about 10, and more preferably at least about 20. Enter a high or low copy number vector may be selected, depending upon the effect of the vector and the foreign protein on the host. See *eg. Brake et al., supra*.

- 5 Alternatively, the expression constructs can be integrated into the yeast genome with an integrating vector. Integrating vectors usually contain at least one sequence homologous to a yeast chromosome that allows the vector to integrate, and preferably contain two homologous sequences flanking the expression construct. Integrations appear to result from recombinations between homologous DNA in the vector and the yeast chromosome [Orr-Weaver *et al.* (1983) *Methods in*
10 *Enzymol.* 101:228-245]. An integrating vector may be directed to a specific locus in yeast by selecting the appropriate homologous sequence for inclusion in the vector. See Orr-Weaver *et al., supra*. One or more expression construct may integrate, possibly affecting levels of recombinant protein produced [Rine *et al.* (1983) *Proc. Natl. Acad. Sci. USA* 80:6750]. The chromosomal sequences included in the vector can occur either as a single segment in the vector, which results
15 in the integration of the entire vector, or two segments homologous to adjacent segments in the chromosome and flanking the expression construct in the vector, which can result in the stable integration of only the expression construct.

- Usually, extrachromosomal and integrating expression constructs may contain selectable markers to allow for the selection of yeast strains that have been transformed. Selectable markers may
20 include biosynthetic genes that can be expressed in the yeast host, such as *ADE2*, *HIS4*, *LEU2*, *TRP1*, and *ALG7*, and the G418 resistance gene, which confer resistance in yeast cells to tunicamycin and G418, respectively. In addition, a suitable selectable marker may also provide yeast with the ability to grow in the presence of toxic compounds, such as metal. For example, the presence of *CUP1* allows yeast to grow in the presence of copper ions [Butt *et al.* (1987) *Microbiol.*
25 *Rev.* 51:351].

Alternatively, some of the above described components can be put together into transformation vectors. Transformation vectors are usually comprised of a selectable marker that is either maintained in a replicon or developed into an integrating vector, as described above.

Expression and transformation vectors, either extrachromosomal replicons or integrating vectors, have been developed for transformation into many yeasts. For example, expression vectors have been developed for, *inter alia*, the following yeasts: *Candida albicans* [Kurtz, *et al.* (1986) *Mol. Cell. Biol.* 6:142], *Candida maltosa* [Kunze, *et al.* (1985) *J. Basic Microbiol.* 25:141], *Hansenula polymorpha* [Gleeson, *et al.* (1986) *J. Gen. Microbiol.* 132:3459; Roggenkamp *et al.* (1986) *Mol. Gen. Genet.* 202:302], *Kluyveromyces fragilis* [Das, *et al.* (1984) *J. Bacteriol.* 158:1165], *Kluyveromyces lactis* [De Louvencourt *et al.* (1983) *J. Bacteriol.* 154:737; Van den Berg *et al.* (1990) *Bio/Technology* 8:135], *Pichia guilliermondii* [Kunze *et al.* (1985) *J. Basic Microbiol.* 25:141], *Pichia pastoris* [Cregg, *et al.* (1985) *Mol. Cell. Biol.* 5:3376; US Patent Nos. 4,837,148 and 4,929,555], *Saccharomyces cerevisiae* [Hinnen *et al.* (1978) *Proc. Natl. Acad. Sci. USA* 75:1929; Ito *et al.* (1983) *J. Bacteriol.* 153:163], *Schizosaccharomyces pombe* [Beach and Nurse (1981) *Nature* 300:706], and *Yarrowia lipolytica* [Davidow, *et al.* (1985) *Curr. Genet.* 10:380471 Gaillardin, *et al.* (1985) *Curr. Genet.* 10:49].

Methods of introducing exogenous DNA into yeast hosts are well-known in the art, and usually include either the transformation of spheroplasts or of intact yeast cells treated with alkali cations. Transformation procedures usually vary with the yeast species to be transformed. See *eg.* [Kurtz *et al.* (1986) *Mol. Cell. Biol.* 6:142; Kunze *et al.* (1985) *J. Basic Microbiol.* 25:141; *Candida*]; [Gleeson *et al.* (1986) *J. Gen. Microbiol.* 132:3459; Roggenkamp *et al.* (1986) *Mol. Gen. Genet.* 202:302; *Hansenula*]; [Das *et al.* (1984) *J. Bacteriol.* 158:1165; De Louvencourt *et al.* (1983) *J. Bacteriol.* 154:1165; Van den Berg *et al.* (1990) *Bio/Technology* 8:135; *Kluyveromyces*]; [Cregg *et al.* (1985) *Mol. Cell. Biol.* 5:3376; Kunze *et al.* (1985) *J. Basic Microbiol.* 25:141; US Patent Nos. 4,837,148 and 4,929,555; *Pichia*]; [Hinnen *et al.* (1978) *Proc. Natl. Acad. Sci. USA* 75:1929; Ito *et al.* (1983) *J. Bacteriol.* 153:163 *Saccharomyces*]; [Beach and Nurse (1981) *Nature* 300:706; *Schizosaccharomyces*]; [Davidow *et al.* (1985) *Curr. Genet.* 10:39; Gaillardin *et al.* (1985) *Curr. Genet.* 10:49; *Yarrowia*].

Antibodies

As used herein, the term "antibody" refers to a polypeptide or group of polypeptides composed of at least one antibody combining site. An "antibody combining site" is the three-dimensional binding space with an internal surface shape and charge distribution complementary to the features of an epitope of an antigen, which allows a binding of the antibody with the antigen. "Antibody"

includes, for example, vertebrate antibodies, hybrid antibodies, chimeric antibodies, humanised antibodies, altered antibodies, univalent antibodies, Fab proteins, and single domain antibodies.

Antibodies against the proteins of the invention are useful for affinity chromatography, immunoassays, and distinguishing/identifying Neisserial proteins.

- 5 Antibodies to the proteins of the invention, both polyclonal and monoclonal, may be prepared by conventional methods. In general, the protein is first used to immunize a suitable animal, preferably a mouse, rat, rabbit or goat. Rabbits and goats are preferred for the preparation of polyclonal sera due to the volume of serum obtainable, and the availability of labeled anti-rabbit and anti-goat antibodies. Immunization is generally performed by mixing or emulsifying the protein in saline,
- 10 preferably in an adjuvant such as Freund's complete adjuvant, and injecting the mixture or emulsion parenterally (generally subcutaneously or intramuscularly). A dose of 50-200 µg/injection is typically sufficient. Immunization is generally boosted 2-6 weeks later with one or more injections of the protein in saline, preferably using Freund's incomplete adjuvant. One may alternatively generate antibodies by *in vitro* immunization using methods known in the art, which
- 15 for the purposes of this invention is considered equivalent to *in vivo* immunization. Polyclonal antisera is obtained by bleeding the immunized animal into a glass or plastic container, incubating the blood at 25°C for one hour, followed by incubating at 4°C for 2-18 hours. The serum is recovered by centrifugation (eg. 1,000g for 10 minutes). About 20-50 ml per bleed may be obtained from rabbits.
- 20 Monoclonal antibodies are prepared using the standard method of Kohler & Milstein [*Nature* (1975) 256:495-96], or a modification thereof. Typically, a mouse or rat is immunized as described above. However, rather than bleeding the animal to extract serum, the spleen (and optionally several large lymph nodes) is removed and dissociated into single cells. If desired, the spleen cells may be screened (after removal of nonspecifically adherent cells) by applying a cell suspension to
- 25 a plate or well coated with the protein antigen. B-cells expressing membrane-bound immunoglobulin specific for the antigen bind to the plate, and are not rinsed away with the rest of the suspension. Resulting B-cells, or all dissociated spleen cells, are then induced to fuse with myeloma cells to form hybridomas, and are cultured in a selective medium (eg. hypoxanthine, aminopterin, thymidine medium, "HAT"). The resulting hybridomas are plated by limiting dilution,
- 30 and are assayed for the production of antibodies which bind specifically to the immunizing antigen

(and which do not bind to unrelated antigens). The selected MAb-secreting hybridomas are then cultured either *in vitro* (eg. in tissue culture bottles or hollow fiber reactors), or *in vivo* (as ascites in mice).

If desired, the antibodies (whether polyclonal or monoclonal) may be labeled using conventional techniques. Suitable labels include fluorophores, chromophores, radioactive atoms (particularly ^{32}P and ^{125}I), electron-dense reagents, enzymes, and ligands having specific binding partners. Enzymes are typically detected by their activity. For example, horseradish peroxidase is usually detected by its ability to convert 3,3',5,5'-tetramethylbenzidine (TMB) to a blue pigment, quantifiable with a spectrophotometer. "Specific binding partner" refers to a protein capable of binding a ligand molecule with high specificity, as for example in the case of an antigen and a monoclonal antibody specific therefor. Other specific binding partners include biotin and avidin or streptavidin, IgG and protein A, and the numerous receptor-ligand couples known in the art. It should be understood that the above description is not meant to categorize the various labels into distinct classes, as the same label may serve in several different modes. For example, ^{125}I may serve as a radioactive label or as an electron-dense reagent. HRP may serve as enzyme or as antigen for a MAb. Further, one may combine various labels for desired effect. For example, MAbs and avidin also require labels in the practice of this invention: thus, one might label a MAb with biotin, and detect its presence with avidin labeled with ^{125}I , or with an anti-biotin MAb labeled with HRP. Other permutations and possibilities will be readily apparent to those of ordinary skill in the art, and are considered as equivalents within the scope of the instant invention.

Pharmaceutical Compositions

Pharmaceutical compositions can comprise either polypeptides, antibodies, or nucleic acid of the invention. The pharmaceutical compositions will comprise a therapeutically effective amount of either polypeptides, antibodies, or polynucleotides of the claimed invention.

The term "therapeutically effective amount" as used herein refers to an amount of a therapeutic agent to treat, ameliorate, or prevent a desired disease or condition, or to exhibit a detectable therapeutic or preventative effect. The effect can be detected by, for example, chemical markers or antigen levels. Therapeutic effects also include reduction in physical symptoms, such as decreased body temperature. The precise effective amount for a subject will depend upon the subject's size and health, the nature and extent of the condition, and the therapeutics or combination of

therapeutics selected for administration. Thus, it is not useful to specify an exact effective amount in advance. However, the effective amount for a given situation can be determined by routine experimentation and is within the judgement of the clinician.

For purposes of the present invention, an effective dose will be from about 0.01 mg/ kg to 50 mg/kg
5 or 0.05 mg/kg to about 10 mg/kg of the DNA constructs in the individual to which it is administered.

A pharmaceutical composition can also contain a pharmaceutically acceptable carrier. The term "pharmaceutically acceptable carrier" refers to a carrier for administration of a therapeutic agent, such as antibodies or a polypeptide, genes, and other therapeutic agents. The term refers to any pharmaceutical carrier that does not itself induce the production of antibodies harmful to the
10 individual receiving the composition, and which may be administered without undue toxicity. Suitable carriers may be large, slowly metabolized macromolecules such as proteins, polysaccharides, polylactic acids, polyglycolic acids, polymeric amino acids, amino acid copolymers, and inactive virus particles. Such carriers are well known to those of ordinary skill in the art.

Pharmaceutically acceptable salts can be used therein, for example, mineral acid salts such as
15 hydrochlorides, hydrobromides, phosphates, sulfates, and the like; and the salts of organic acids such as acetates, propionates, malonates, benzoates, and the like. A thorough discussion of pharmaceutically acceptable excipients is available in Remington's Pharmaceutical Sciences (Mack Pub. Co., N.J. 1991).

Pharmaceutically acceptable carriers in therapeutic compositions may contain liquids such as water,
20 saline, glycerol and ethanol. Additionally, auxiliary substances, such as wetting or emulsifying agents, pH buffering substances, and the like, may be present in such vehicles. Typically, the therapeutic compositions are prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection may also be prepared. Liposomes are included within the definition of a pharmaceutically acceptable carrier.

25 Delivery Methods

Once formulated, the compositions of the invention can be administered directly to the subject. The subjects to be treated can be animals; in particular, human subjects can be treated.

Direct delivery of the compositions will generally be accomplished by injection, either subcutaneously, intraperitoneally, intravenously or intramuscularly or delivered to the interstitial space of a tissue. The compositions can also be administered into a lesion. Other modes of administration include oral and pulmonary administration, suppositories, and transdermal or transcutaneous applications (eg. see WO98/20734), needles, and gene guns or hyposprays. Dosage treatment may be a single dose schedule or a multiple dose schedule.

Vaccines

Vaccines according to the invention may either be prophylactic (*ie.* to prevent infection) or therapeutic (*ie.* to treat disease after infection).

- Such vaccines comprise immunising antigen(s), immunogen(s), polypeptide(s), protein(s) or nucleic acid, usually in combination with "pharmaceutically acceptable carriers," which include any carrier that does not itself induce the production of antibodies harmful to the individual receiving the composition. Suitable carriers are typically large, slowly metabolized macromolecules such as proteins, polysaccharides, polylactic acids, polyglycolic acids, polymeric amino acids, amino acid copolymers, lipid aggregates (such as oil droplets or liposomes), and inactive virus particles. Such carriers are well known to those of ordinary skill in the art. Additionally, these carriers may function as immunostimulating agents ("adjuvants"). Furthermore, the antigen or immunogen may be conjugated to a bacterial toxoid, such as a toxoid from diphtheria, tetanus, cholera, *H. pylori*, etc. pathogens.

- Preferred adjuvants to enhance effectiveness of the composition include, but are not limited to: (1) aluminum salts (alum), such as aluminum hydroxide, aluminum phosphate, aluminum sulfate, etc; (2) oil-in-water emulsion formulations (with or without other specific immunostimulating agents such as muramyl peptides (see below) or bacterial cell wall components), such as for example (a) MF59™ (WO 90/14837; Chapter 10 in *Vaccine design: the subunit and adjuvant approach*, eds. Powell & Newman, Plenum Press 1995), containing 5% Squalene, 0.5% Tween 80, and 0.5% Span 85 (optionally containing various amounts of MTP-PE (see below), although not required) formulated into submicron particles using a microfluidizer such as Model 110Y microfluidizer (Microfluidics, Newton, MA), (b) SAF, containing 10% Squalane, 0.4% Tween 80, 5% pluronic-blocked polymer L121, and thr-MDP (see below) either microfluidized into a submicron emulsion or vortexed to generate a larger particle size emulsion, and (c) Ribi™ adjuvant system (RAS), (Ribi Immunochem, Hamilton, MT) containing 2% Squalene, 0.2% Tween 80, and one or more bacterial

- cell wall components from the group consisting of monophosphorylipid A (MPL), trehalose dimycolate (TDM), and cell wall skeleton (CWS), preferably MPL + CWS (Detox™); (3) saponin adjuvants, such as Stimulon™ (Cambridge Bioscience, Worcester, MA) may be used or particles generated therefrom such as ISCOMs (immunostimulating complexes); (4) Complete Freund's Adjuvant (CFA) and Incomplete Freund's Adjuvant (IFA); (5) cytokines, such as interleukins (*eg.* IL-1, IL-2, IL-4, IL-5, IL-6, IL-7, IL-12, *etc.*), interferons (*eg.* gamma interferon), macrophage colony stimulating factor (M-CSF), tumor necrosis factor (TNF), *etc.*; and (6) other substances that act as immunostimulating agents to enhance the effectiveness of the composition. Alum and MF59™ are preferred.
- 10 As mentioned above, muramyl peptides include, but are not limited to, N-acetyl-muramyl-L-threonyl-D-isoglutamine (thr-MDP), N-acetyl-normuramyl-L-alanyl-D-isoglutamine (nor-MDP), N-acetylmuramyl-L-alanyl-D-isoglutaminyl-L-alanine-2-(1'-2'-dipalmitoyl-*sn*-glycero-3-hydroxyphosphoryloxy)-ethylamine (MTP-PE), *etc.*

- The immunogenic compositions (*eg.* the immunising antigen/immunogen/polypeptide/protein/nucleic acid, pharmaceutically acceptable carrier, and adjuvant) typically will contain diluents, such as water, saline, glycerol, ethanol, *etc.* Additionally, auxiliary substances, such as wetting or emulsifying agents, pH buffering substances, and the like, may be present in such vehicles.
- 15

- Typically, the immunogenic compositions are prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection may also be prepared. The preparation also may be emulsified or encapsulated in liposomes for enhanced adjuvant effect, as discussed above under pharmaceutically acceptable carriers.
- 20

- Immunogenic compositions used as vaccines comprise an immunologically effective amount of the antigenic or immunogenic polypeptides, as well as any other of the above-mentioned components, as needed. By "immunologically effective amount", it is meant that the administration of that amount to an individual, either in a single dose or as part of a series, is effective for treatment or prevention. This amount varies depending upon the health and physical condition of the individual to be treated, the taxonomic group of individual to be treated (*eg.* nonhuman primate, primate, *etc.*), the capacity of the individual's immune system to synthesize antibodies, the degree of protection desired, the formulation of the vaccine, the treating doctor's assessment of the medical situation,
- 25

and other relevant factors. It is expected that the amount will fall in a relatively broad range that can be determined through routine trials.

The immunogenic compositions are conventionally administered parenterally, *eg.* by injection, either subcutaneously, intramuscularly, or transdermally/transcutaneously (*eg.* WO98/20734).

- 5 Additional formulations suitable for other modes of administration include oral and pulmonary formulations, suppositories, and transdermal applications. Dosage treatment may be a single dose schedule or a multiple dose schedule. The vaccine may be administered in conjunction with other immunoregulatory agents.

- 10 As an alternative to protein-based vaccines, DNA vaccination may be employed [*eg.* Robinson & Torres (1997) *Seminars in Immunology* 9:271-283; Donnelly *et al.* (1997) *Annu Rev Immunol* 15:617-648; see later herein].

Gene Delivery Vehicles

- 15 Gene therapy vehicles for delivery of constructs including a coding sequence of a therapeutic of the invention, to be delivered to the mammal for expression in the mammal, can be administered either locally or systemically. These constructs can utilize viral or non-viral vector approaches in *in vivo* or *ex vivo* modality. Expression of such coding sequence can be induced using endogenous mammalian or heterologous promoters. Expression of the coding sequence *in vivo* can be either constitutive or regulated.

- 20 The invention includes gene delivery vehicles capable of expressing the contemplated nucleic acid sequences. The gene delivery vehicle is preferably a viral vector and, more preferably, a retroviral, adenoviral, adeno-associated viral (AAV), herpes viral, or alphavirus vector. The viral vector can also be an astrovirus, coronavirus, orthomyxovirus, papovavirus, paramyxovirus, parvovirus, picomavirus, poxvirus, or togavirus viral vector. See generally, Jolly (1994) *Cancer Gene Therapy* 1:51-64; Kimura (1994) *Human Gene Therapy* 5:845-852; Connelly (1995) *Human Gene Therapy* 25 6:185-193; and Kaplitt (1994) *Nature Genetics* 6:148-153.

Retroviral vectors are well known in the art and we contemplate that any retroviral gene therapy vector is employable in the invention, including B, C and D type retroviruses, xenotropic retroviruses (for example, NZB-X1, NZB-X2 and NZB9-1 (see O'Neill (1985) *J. Virol.* 53:160) polytropic retroviruses

eg. MCF and MCF-MLV (see Kelly (1983) *J. Virol.* 45:291), spumaviruses and lentiviruses. See RNA Tumor Viruses, Second Edition, Cold Spring Harbor Laboratory, 1985.

Portions of the retroviral gene therapy vector may be derived from different retroviruses. For example, retrovector LTRs may be derived from a Murine Sarcoma Virus, a tRNA binding site
5 from a Rous Sarcoma Virus, a packaging signal from a Murine Leukemia Virus, and an origin of second strand synthesis from an Avian Leukosis Virus.

These recombinant retroviral vectors may be used to generate transduction competent retroviral vector particles by introducing them into appropriate packaging cell lines (see US patent 5,591,624). Retrovirus vectors can be constructed for site-specific integration into host cell DNA
10 by incorporation of a chimeric integrase enzyme into the retroviral particle (see WO96/37626). It is preferable that the recombinant viral vector is a replication defective recombinant virus.

Packaging cell lines suitable for use with the above-described retrovirus vectors are well known in the art, are readily prepared (see WO95/30763 and WO92/05266), and can be used to create producer cell lines (also termed vector cell lines or "VCLs") for the production of recombinant
15 vector particles. Preferably, the packaging cell lines are made from human parent cells (eg. HT1080 cells) or mink parent cell lines, which eliminates inactivation in human serum.

Preferred retroviruses for the construction of retroviral gene therapy vectors include Avian Leukosis Virus, Bovine Leukemia Virus, Murine Leukemia Virus, Mink-Cell Focus-Inducing Virus, Murine Sarcoma Virus, Reticuloendotheliosis Virus and Rous Sarcoma Virus. Particularly
20 preferred Murine Leukemia Viruses include 4070A and 1504A (Hartley and Rowe (1976) *J Virol* 19:19-25), Abelson (ATCC No. VR-999), Friend (ATCC No. VR-245), Graffi, Gross (ATCC No. VR-590), Kirsten, Harvey Sarcoma Virus and Rauscher (ATCC No. VR-998) and Moloney Murine Leukemia Virus (ATCC No. VR-190). Such retroviruses may be obtained from depositories or collections such as the American Type Culture Collection ("ATCC") in Rockville, Maryland or
25 isolated from known sources using commonly available techniques.

Exemplary known retroviral gene therapy vectors employable in this invention include those described in patent applications GB2200651, EP0415731, EP0345242, EP0334301, WO89/02468; WO89/05349, WO89/09271, WO90/02806, WO90/07936, WO94/03622, WO93/25698,

WO93/25234, WO93/11230, WO93/10218, WO91/02805, WO91/02825, WO95/07994, US 5,219,740, US 4,405,712, US 4,861,719, US 4,980,289, US 4,777,127, US 5,591,624. See also Vile (1993) *Cancer Res* 53:3860-3864; Vile (1993) *Cancer Res* 53:962-967; Ram (1993) *Cancer Res* 53 (1993) 83-88; Takamiya (1992) *J Neurosci Res* 33:493-503; Baba (1993) *J Neurosurg* 79:729-735; Mann (1983) *Cell* 33:153; Cane (1984) *Proc Natl Acad Sci* 81:6349; and Miller (1990) *Human Gene Therapy* 1.

Human adenoviral gene therapy vectors are also known in the art and employable in this invention. See, for example, Berkner (1988) *Biotechniques* 6:616 and Rosenfeld (1991) *Science* 252:431, and WO93/07283, WO93/06223, and WO93/07282. Exemplary known adenoviral gene therapy vectors employable in this invention include those described in the above referenced documents and in WO94/12649, WO93/03769, WO93/19191, WO94/28938, WO95/11984, WO95/00655, WO95/27071, WO95/29993, WO95/34671, WO96/05320, WO94/08026, WO94/11506, WO93/06223, WO94/24299, WO95/14102, WO95/24297, WO95/02697, WO94/28152, WO94/24299, WO95/09241, WO95/25807, WO95/05835, WO94/18922 and WO95/09654.

Alternatively, administration of DNA linked to killed adenovirus as described in Curiel (1992) *Hum. Gene Ther.* 3:147-154 may be employed. The gene delivery vehicles of the invention also include adenovirus associated virus (AAV) vectors. Leading and preferred examples of such vectors for use in this invention are the AAV-2 based vectors disclosed in Srivastava, WO93/09239. Most preferred AAV vectors comprise the two AAV inverted terminal repeats in which the native D-sequences are modified by substitution of nucleotides, such that at least 5 native nucleotides and up to 18 native nucleotides, preferably at least 10 native nucleotides up to 18 native nucleotides, most preferably 10 native nucleotides are retained and the remaining nucleotides of the D-sequence are deleted or replaced with non-native nucleotides. The native D-sequences of the AAV inverted terminal repeats are sequences of 20 consecutive nucleotides in each AAV inverted terminal repeat (*ie.* there is one sequence at each end) which are not involved in HP formation. The non-native replacement nucleotide may be any nucleotide other than the nucleotide found in the native D-sequence in the same position. Other employable exemplary AAV vectors are pWP-19, pWN-1, both of which are disclosed in Nahreini (1993) *Gene* 124:257-262. Another example of such an AAV vector is psub201 (see Samulski (1987) *J. Virol.* 61:3096). Another exemplary AAV vector is the Double-D ITR vector. Construction of the Double-D ITR vector is disclosed in US Patent 5,478,745. Still other vectors are those disclosed in Carter US Patent 4,797,368 and

Muzyczka US Patent 5,139,941, Chartejee US Patent 5,474,935, and Kotin WO94/288157. Yet a further example of an AAV vector employable in this invention is SSV9AFABTKneo, which contains the AFP enhancer and albumin promoter and directs expression predominantly in the liver. Its structure and construction are disclosed in Su (1996) *Human Gene Therapy* 7:463-470.

- 5 Additional AAV gene therapy vectors are described in US 5,354,678, US 5,173,414, US 5,139,941, and US 5,252,479.

- The gene therapy vectors of the invention also include herpes vectors. Leading and preferred examples are herpes simplex virus vectors containing a sequence encoding a thymidine kinase polypeptide such as those disclosed in US 5,288,641 and EP0176170 (Roizman). Additional
10 exemplary herpes simplex virus vectors include HFEM/ICP6-LacZ disclosed in WO95/04139 (Wistar Institute), pHSVlac described in Geller (1988) *Science* 241:1667-1669 and in WO90/09441 and WO92/07945, HSV Us3::pgC-lacZ described in Fink (1992) *Human Gene Therapy* 3:11-19 and HSV 7134, 2 RH 105 and GAL4 described in EP 0453242 (Breakefield), and those deposited with the ATCC as accession numbers ATCC VR-977 and ATCC VR-260.

- 15 Also contemplated are alpha virus gene therapy vectors that can be employed in this invention. Preferred alpha virus vectors are Sindbis viruses vectors. Togaviruses, Semliki Forest virus (ATCC VR-67; ATCC VR-1247), Middleberg virus (ATCC VR-370), Ross River virus (ATCC VR-373; ATCC VR-1246), Venezuelan equine encephalitis virus (ATCC VR923; ATCC VR-1250; ATCC VR-1249; ATCC VR-532), and those described in US patents 5,091,309, 5,217,879, and
20 WO92/10578. More particularly, those alpha virus vectors described in US Serial No. 08/405,627, filed March 15, 1995, WO94/21792, WO92/10578, WO95/07994, US 5,091,309 and US 5,217,879 are employable. Such alpha viruses may be obtained from depositories or collections such as the ATCC in Rockville, Maryland or isolated from known sources using commonly available techniques. Preferably, alphavirus vectors with reduced cytotoxicity are used (see USSN
25 08/679640).

DNA vector systems such as eukaryotic layered expression systems are also useful for expressing the nucleic acids of the invention. See WO95/07994 for a detailed description of eukaryotic layered expression systems. Preferably, the eukaryotic layered expression systems of the invention are derived from alphavirus vectors and most preferably from Sindbis viral vectors.

Other viral vectors suitable for use in the present invention include those derived from poliovirus, for example ATCC VR-58 and those described in Evans, *Nature* 339 (1989) 385 and Sabin (1973) *J. Biol. Standardization* 1:115; rhinovirus, for example ATCC VR-1110 and those described in Arnold (1990) *J Cell Biochem* L401; pox viruses such as canary pox virus or vaccinia virus, for example ATCC VR-111 and ATCC VR-2010 and those described in Fisher-Hoch (1989) *Proc Natl Acad Sci* 86:317; Flexner (1989) *Ann NY Acad Sci* 569:86, Flexner (1990) *Vaccine* 8:17; in US 4,603,112 and US 4,769,330 and WO89/01973; SV40 virus, for example ATCC VR-305 and those described in Mulligan (1979) *Nature* 277:108 and Madzak (1992) *J Gen Virol* 73:1533; influenza virus, for example ATCC VR-797 and recombinant influenza viruses made employing reverse genetics techniques as described in US 5,166,057 and in Enami (1990) *Proc Natl Acad Sci* 87:3802-3805; Enami & Palese (1991) *J Virol* 65:2711-2713 and Luytjes (1989) *Cell* 59:110, (see also McMichael (1983) *NEJ Med* 309:13, and Yap (1978) *Nature* 273:238 and *Nature* (1979) 277:108); human immunodeficiency virus as described in EP-0386882 and in Buchschacher (1992) *J. Virol.* 66:2731; measles virus, for example ATCC VR-67 and VR-1247 and those described in EP-0440219; Aura virus, for example ATCC VR-368; Bebaru virus, for example ATCC VR-600 and ATCC VR-1240; Cabassou virus, for example ATCC VR-922; Chikungunya virus, for example ATCC VR-64 and ATCC VR-1241; Fort Morgan Virus, for example ATCC VR-924; Getah virus, for example ATCC VR-369 and ATCC VR-1243; Kyzylagach virus, for example ATCC VR-927; Mayaro virus, for example ATCC VR-66; Mucambo virus, for example ATCC VR-580 and ATCC VR-1244; Ndumu virus, for example ATCC VR-371; Pixuna virus, for example ATCC VR-372 and ATCC VR-1245; Tonate virus, for example ATCC VR-925; Trinita virus, for example ATCC VR-469; Una virus, for example ATCC VR-374; Whataroa virus, for example ATCC VR-926; Y-62-33 virus, for example ATCC VR-375; O'Nyong virus, Eastern encephalitis virus, for example ATCC VR-65 and ATCC VR-1242; Western encephalitis virus, for example ATCC VR-70, ATCC VR-1251, ATCC VR-622 and ATCC VR-1252; and coronavirus, for example ATCC VR-740 and those described in Hamre (1966) *Proc Soc Exp Biol Med* 121:190.

Delivery of the compositions of this invention into cells is not limited to the above mentioned viral vectors. Other delivery methods and media may be employed such as, for example, nucleic acid expression vectors, polycationic condensed DNA linked or unlinked to killed adenovirus alone, for example see US Serial No. 08/366,787, filed December 30, 1994 and Curiel (1992) *Hum Gene Ther* 3:147-154 ligand linked DNA, for example see Wu (1989) *J Biol Chem* 264:16985-16987, eucaryotic cell delivery vehicles cells, for example see US Serial No.08/240,030, filed May 9,

1994, and US Serial No. 08/404,796, deposition of photopolymerized hydrogel materials, hand-held gene transfer particle gun, as described in US Patent 5,149,655, ionizing radiation as described in US5,206,152 and in WO92/11033, nucleic charge neutralization or fusion with cell membranes. Additional approaches are described in Philip (1994) *Mol Cell Biol* 14:2411-2418 and
5 in Woffendin (1994) *Proc Natl Acad Sci* 91:1581-1585.

Particle mediated gene transfer may be employed, for example see US Serial No. 60/023,867. Briefly, the sequence can be inserted into conventional vectors that contain conventional control sequences for high level expression, and then incubated with synthetic gene transfer molecules such as polymeric DNA-binding cations like polylysine, protamine, and albumin, linked to cell targeting
10 ligands such as asialoorosomucoid, as described in Wu & Wu (1987) *J. Biol. Chem.* 262:4429-4432, insulin as described in Hucked (1990) *Biochem Pharmacol* 40:253-263, galactose as described in Plank (1992) *Bioconjugate Chem* 3:533-539, lactose or transferrin.

Naked DNA may also be employed. Exemplary naked DNA introduction methods are described in WO 90/11092 and US 5,580,859. Uptake efficiency may be improved using biodegradable latex
15 beads. DNA coated latex beads are efficiently transported into cells after endocytosis initiation by the beads. The method may be improved further by treatment of the beads to increase hydrophobicity and thereby facilitate disruption of the endosome and release of the DNA into the cytoplasm.

Liposomes that can act as gene delivery vehicles are described in US 5,422,120, WO95/13796, WO94/23697, WO91/14445 and EP-524,968. As described in USSN. 60/023,867, on non-viral
20 delivery, the nucleic acid sequences encoding a polypeptide can be inserted into conventional vectors that contain conventional control sequences for high level expression, and then be incubated with synthetic gene transfer molecules such as polymeric DNA-binding cations like polylysine, protamine, and albumin, linked to cell targeting ligands such as asialoorosomucoid, insulin, galactose, lactose, or transferrin. Other delivery systems include the use of liposomes to encapsulate
25 DNA comprising the gene under the control of a variety of tissue-specific or ubiquitously-active promoters. Further non-viral delivery suitable for use includes mechanical delivery systems such as the approach described in Woffendin *et al* (1994) *Proc. Natl. Acad. Sci. USA* 91(24):11581-11585. Moreover, the coding sequence and the product of expression of such can be delivered through deposition of photopolymerized hydrogel materials. Other conventional methods
30 for gene delivery that can be used for delivery of the coding sequence include, for example, use of

hand-held gene transfer particle gun, as described in US 5,149,655; use of ionizing radiation for activating transferred gene, as described in US 5,206,152 and WO92/11033

Exemplary liposome and polycationic gene delivery vehicles are those described in US 5,422,120 and 4,762,915; in WO 95/13796; WO94/23697; and WO91/14445; in EP-0524968; and in Stryer, 5 Biochemistry, pages 236-240 (1975) W.H. Freeman, San Francisco; Szoka (1980) *Biochem Biophys Acta* 600:1; Bayer (1979) *Biochem Biophys Acta* 550:464; Rivnay (1987) *Meth Enzymol* 149:119; Wang (1987) *Proc Natl Acad Sci* 84:7851; Plant (1989) *Anal Biochem* 176:420.

A polynucleotide composition can comprises therapeutically effective amount of a gene therapy vehicle, as the term is defined above. For purposes of the present invention, an effective dose will 10 be from about 0.01 mg/ kg to 50 mg/kg or 0.05 mg/kg to about 10 mg/kg of the DNA constructs in the individual to which it is administered.

Delivery Methods

Once formulated, the polynucleotide compositions of the invention can be administered (1) directly to the subject; (2) delivered *ex vivo*, to cells derived from the subject; or (3) *in vitro* for expression 15 of recombinant proteins. The subjects to be treated can be mammals or birds. Also, human subjects can be treated.

Direct delivery of the compositions will generally be accomplished by injection, either subcutaneously, intraperitoneally, intravenously or intramuscularly or delivered to the interstitial space of a tissue. The compositions can also be administered into a lesion. Other modes of 20 administration include oral and pulmonary administration, suppositories, and transdermal or transcutaneous applications (eg. see WO98/20734), needles, and gene guns or hyposprays. Dosage treatment may be a single dose schedule or a multiple dose schedule.

Methods for the *ex vivo* delivery and reimplantation of transformed cells into a subject are known in the art and described in eg. WO93/14778. Examples of cells useful in *ex vivo* applications 25 include, for example, stem cells, particularly hematopoietic, lymph cells, macrophages, dendritic cells, or tumor cells.

Generally, delivery of nucleic acids for both *ex vivo* and *in vitro* applications can be accomplished by the following procedures, for example, dextran-mediated transfection, calcium phosphate precipitation, polybrene mediated transfection, protoplast fusion, electroporation, encapsulation of the polynucleotide(s) in liposomes, and direct microinjection of the DNA into nuclei, all well known in the art.

Polynucleotide and polypeptide pharmaceutical compositions

In addition to the pharmaceutically acceptable carriers and salts described above, the following additional agents can be used with polynucleotide and/or polypeptide compositions.

A. Polypeptides

- One example are polypeptides which include, without limitation: asioloorosomucoid (ASOR); transferrin; asialoglycoproteins; antibodies; antibody fragments; ferritin; interleukins; interferons, granulocyte, macrophage colony stimulating factor (GM-CSF), granulocyte colony stimulating factor (G-CSF), macrophage colony stimulating factor (M-CSF), stem cell factor and erythropoietin. Viral antigens, such as envelope proteins, can also be used. Also, proteins from other invasive organisms, such as the 17 amino acid peptide from the circumsporozoite protein of plasmodium falciparum known as RII.

B. Hormones, Vitamins, etc.

Other groups that can be included are, for example: hormones, steroids, androgens, estrogens, thyroid hormone, or vitamins, folic acid.

C. Polyalkylenes, Polysaccharides, etc.

Also, polyalkylene glycol can be included with the desired polynucleotides/polypeptides. In a preferred embodiment, the polyalkylene glycol is polyethylene glycol. In addition, mono-, di-, or polysaccharides can be included. In a preferred embodiment of this aspect, the polysaccharide is dextran or DEAE-dextran. Also, chitosan and poly(lactide-co-glycolide)

D. Lipids, and Liposomes

The desired polynucleotide/polypeptide can also be encapsulated in lipids or packaged in liposomes prior to delivery to the subject or to cells derived therefrom.

Lipid encapsulation is generally accomplished using liposomes which are able to stably bind or entrap and retain nucleic acid. The ratio of condensed polynucleotide to lipid preparation can vary but will generally be around 1:1 (mg DNA:micromoles lipid), or more of lipid. For a review of the use of liposomes as carriers for delivery of nucleic acids, see, Hug and Sleight (1991) *Biochim. Biophys. Acta*. 1097:1-17; Straubinger (1983) *Meth. Enzymol.* 101:512-527.

Liposomal preparations for use in the present invention include cationic (positively charged), anionic (negatively charged) and neutral preparations. Cationic liposomes have been shown to mediate intracellular delivery of plasmid DNA (Felgner (1987) *Proc. Natl. Acad. Sci. USA* 84:7413-7416); mRNA (Malone (1989) *Proc. Natl. Acad. Sci. USA* 86:6077-6081); and purified transcription factors (Debs (1990) *J. Biol. Chem.* 265:10189-10192), in functional form.

Cationic liposomes are readily available. For example, N[1-2,3-dioleoyloxy)propyl]-N,N,N-triethylammonium (DOTMA) liposomes are available under the trademark Lipofectin, from GIBCO BRL, Grand Island, NY.-(See, also, Felgner *supra*). Other commercially available liposomes include transfectace (DDAB/DOPE) and DOTAP/DOPE (Boehringer). Other cationic liposomes can be prepared from readily available materials using techniques well known in the art. See, *eg.* Szoka (1978) *Proc. Natl. Acad. Sci. USA* 75:4194-4198; WO90/11092 for a description of the synthesis of DOTAP (1,2-bis(oleoyloxy)-3-(trimethylammonio)propane) liposomes.

Similarly, anionic and neutral liposomes are readily available, such as from Avanti Polar Lipids (Birmingham, AL), or can be easily prepared using readily available materials. Such materials include phosphatidyl choline, cholesterol, phosphatidyl ethanolamine, dioleoylphosphatidyl choline (DOPC), dioleoylphosphatidyl glycerol (DOPG), dioleoylphosphatidyl ethanolamine (DOPE), among others. These materials can also be mixed with the DOTMA and DOTAP starting materials in appropriate ratios. Methods for making liposomes using these materials are well known in the art.

The liposomes can comprise multilammellar vesicles (MLVs), small unilamellar vesicles (SUVs), or large unilamellar vesicles (LUVs). The various liposome-nucleic acid complexes are prepared using methods known in the art. See *eg.* Straubinger (1983) *Meth. Immunol.* 101:512-527; Szoka (1978) *Proc. Natl. Acad. Sci. USA* 75:4194-4198; Papahadjopoulos (1975) *Biochim. Biophys. Acta* 394:483; Wilson (1979) *Cell* 17:77; Deamer & Bangham (1976) *Biochim. Biophys. Acta* 443:629; Ostro (1977) *Biochem. Biophys. Res. Commun.* 76:836; Fraley (1979) *Proc. Natl. Acad. Sci. USA*

76:3348); Enoch & Strittmatter (1979) *Proc. Natl. Acad. Sci. USA* 76:145; Fraley (1980) *J. Biol. Chem.* (1980) 255:10431; Szoka & Papahadjopoulos (1978) *Proc. Natl. Acad. Sci. USA* 75:145; and Schaefer-Ridder (1982) *Science* 215:166.

E.Lipoproteins

- 5 In addition, lipoproteins can be included with the polynucleotide/polypeptide to be delivered. Examples of lipoproteins to be utilized include: chylomicrons, HDL, IDL, LDL, and VLDL. Mutants, fragments, or fusions of these proteins can also be used. Also, modifications of naturally occurring lipoproteins can be used, such as acetylated LDL. These lipoproteins can target the delivery of polynucleotides to cells expressing lipoprotein receptors. Preferably, if lipoproteins are including with
10 the polynucleotide to be delivered, no other targeting ligand is included in the composition.

Naturally occurring lipoproteins comprise a lipid and a protein portion. The protein portion are known as apoproteins. At the present, apoproteins A, B, C, D, and E have been isolated and identified. At least two of these contain several proteins, designated by Roman numerals, AI, AII, AIV; CI, CII, CIII.

- 15 A lipoprotein can comprise more than one apoprotein. For example, naturally occurring chylomicrons comprises of A, B, C, and E, over time these lipoproteins lose A and acquire C and E apoproteins. VLDL comprises A, B, C, and E apoproteins, LDL comprises apoprotein B; and HDL comprises apoproteins A, C, and E.

- The amino acid of these apoproteins are known and are described in, for example, Breslow (1985)
20 *Annu Rev. Biochem* 54:699; Law (1986) *Adv. Exp Med. Biol.* 151:162; Chen (1986) *J Biol Chem* 261:12918; Kane (1980) *Proc Natl Acad Sci USA* 77:2465; and Utermann (1984) *Hum Genet* 65:232.

- Lipoproteins contain a variety of lipids including, triglycerides, cholesterol (free and esters), and phospholipids. The composition of the lipids varies in naturally occurring lipoproteins. For example, chylomicrons comprise mainly triglycerides. A more detailed description of the lipid
25 content of naturally occurring lipoproteins can be found, for example, in *Meth. Enzymol.* 128 (1986). The composition of the lipids are chosen to aid in conformation of the apoprotein for receptor binding activity. The composition of lipids can also be chosen to facilitate hydrophobic interaction and association with the polynucleotide binding molecule.

Naturally occurring lipoproteins can be isolated from serum by ultracentrifugation, for instance. Such methods are described in *Meth. Enzymol.* (*supra*); Pitas (1980) *J. Biochem.* 255:5454-5460 and Mahey (1979) *J Clin. Invest* 64:743-750. Lipoproteins can also be produced by *in vitro* or recombinant methods by expression of the apoprotein genes in a desired host cell. See, for example, 5 Atkinson (1986) *Annu Rev Biophys Chem* 15:403 and Radding (1958) *Biochim Biophys Acta* 30: 443. Lipoproteins can also be purchased from commercial suppliers, such as Biomedical Technologies, Inc., Stoughton, Massachusetts, USA. Further description of lipoproteins can be found in Zuckermann *et al.* PCT/US97/14465.

F. Polycationic Agents

10 Polycationic agents can be included, with or without lipoprotein, in a composition with the desired polynucleotide/polypeptide to be delivered.

Polycationic agents, typically, exhibit a net positive charge at physiological relevant pH and are capable of neutralizing the electrical charge of nucleic acids to facilitate delivery to a desired location. These agents have both *in vitro*, *ex vivo*, and *in vivo* applications. Polycationic agents can 15 be used to deliver nucleic acids to a living subject either intramuscularly, subcutaneously, etc.

The following are examples of useful polypeptides as polycationic agents: polylysine, polyarginine, polyornithine, and protamine. Other examples include histones, protamines, human serum albumin, DNA binding proteins, non-histone chromosomal proteins, coat proteins from DNA viruses, such as (X174, transcriptional factors also contain domains that bind DNA and therefore may be useful 20 as nucleic acid condensing agents. Briefly, transcriptional factors such as C/CEBP, c-jun, c-fos, AP-1, AP-2, AP-3, CPF, Prot-1, Sp-1, Oct-1, Oct-2, CREP, and TFIID contain basic domains that bind DNA sequences.

Organic polycationic agents include: spermine, spermidine, and putrescine.

The dimensions and of the physical properties of a polycationic agent can be extrapolated from the 25 list above, to construct other polypeptide polycationic agents or to produce synthetic polycationic agents.

Synthetic polycationic agents which are useful include, for example, DEAE-dextran, polybrene. Lipofectin™, and lipofectAMINE™ are monomers that form polycationic complexes when combined with polynucleotides/polypeptides.

Immunodiagnostic Assays

- 5 Neisserial antigens of the invention can be used in immunoassays to detect antibody levels (or, conversely, anti-Neisserial antibodies can be used to detect antigen levels). Immunoassays based on well defined, recombinant antigens can be developed to replace invasive diagnostics methods. Antibodies to Neisserial proteins within biological samples, including for example, blood or serum samples, can be detected. Design of the immunoassays is subject to a great deal of variation, and
- 10 a variety of these are known in the art. Protocols for the immunoassay may be based, for example, upon competition, or direct reaction, or sandwich type assays. Protocols may also, for example, use solid supports, or may be by immunoprecipitation. Most assays involve the use of labeled antibody or polypeptide; the labels may be, for example, fluorescent, chemiluminescent, radioactive, or dye molecules. Assays which amplify the signals from the probe are also known; examples of which
- 15 are assays which utilize biotin and avidin, and enzyme-labeled and mediated immunoassays, such as ELISA assays.

- Kits suitable for immunodiagnosis and containing the appropriate labeled reagents are constructed by packaging the appropriate materials, including the compositions of the invention, in suitable containers, along with the remaining reagents and materials (for example, suitable buffers, salt
- 20 solutions, *etc.*) required for the conduct of the assay, as well as suitable set of assay instructions.

Nucleic Acid Hybridisation

- "Hybridization" refers to the association of two nucleic acid sequences to one another by hydrogen bonding. Typically, one sequence will be fixed to a solid support and the other will be free in solution. Then, the two sequences will be placed in contact with one another under conditions that favor
- 25 hydrogen bonding. Factors that affect this bonding include: the type and volume of solvent; reaction temperature; time of hybridization; agitation; agents to block the non-specific attachment of the liquid phase sequence to the solid support (Denhardt's reagent or BLOTTO); concentration of the sequences; use of compounds to increase the rate of association of sequences (dextran sulfate or polyethylene glycol); and the stringency of the washing conditions following hybridization. See Sambrook *et al.*
- 30 [*supra*] Volume 2, chapter 9, pages 9.47 to 9.57.

“Stringency” refers to conditions in a hybridization reaction that favor association of very similar sequences over sequences that differ. For example, the combination of temperature and salt concentration should be chosen that is approximately 120 to 200°C below the calculated T_m of the hybrid under study. The temperature and salt conditions can often be determined empirically in preliminary experiments in which samples of genomic DNA immobilized on filters are hybridized to the sequence of interest and then washed under conditions of different stringencies. See Sambrook *et al.* at page 9.50.

Variables to consider when performing, for example, a Southern blot are (1) the complexity of the DNA being blotted and (2) the homology between the probe and the sequences being detected. The total amount of the fragment(s) to be studied can vary a magnitude of 10, from 0.1 to 1 µg for a plasmid or phage digest to 10^{-9} to 10^{-8} g for a single copy gene in a highly complex eukaryotic genome. For lower complexity polynucleotides, substantially shorter blotting, hybridization, and exposure times, a smaller amount of starting polynucleotides, and lower specific activity of probes can be used. For example, a single-copy yeast gene can be detected with an exposure time of only 1 hour starting with 1 µg of yeast DNA, blotting for two hours, and hybridizing for 4-8 hours with a probe of 10^8 cpm/µg. For a single-copy mammalian gene a conservative approach would start with 10 µg of DNA, blot overnight, and hybridize overnight in the presence of 10% dextran sulfate using a probe of greater than 10^8 cpm/µg, resulting in an exposure time of ~24 hours.

Several factors can affect the melting temperature (T_m) of a DNA-DNA hybrid between the probe and the fragment of interest, and consequently, the appropriate conditions for hybridization and washing. In many cases the probe is not 100% homologous to the fragment. Other commonly encountered variables include the length and total G+C content of the hybridizing sequences and the ionic strength and formamide content of the hybridization buffer. The effects of all of these factors can be approximated by a single equation:

$$T_m = 81 + 16.6(\log_{10} C_i) + 0.4[\%(G + C)] - 0.6(\%\text{formamide}) - 600/n - 1.5(\%\text{mismatch}).$$

where C_i is the salt concentration (monovalent ions) and n is the length of the hybrid in base pairs (slightly modified from Meinkoth & Wahl (1984) *Anal. Biochem.* 138: 267-284).

In designing a hybridization experiment, some factors affecting nucleic acid hybridization can be conveniently altered. The temperature of the hybridization and washes and the salt concentration during the washes are the simplest to adjust. As the temperature of the hybridization increases (*ie.* stringency), it becomes less likely for hybridization to occur between strands that are nonhomologous, and as a result, background decreases. If the radiolabeled probe is not completely homologous with the immobilized fragment (as is frequently the case in gene family and interspecies hybridization experiments), the hybridization temperature must be reduced, and background will increase. The temperature of the washes affects the intensity of the hybridizing band and the degree of background in a similar manner. The stringency of the washes is also increased with decreasing salt concentrations.

In general, convenient hybridization temperatures in the presence of 50% formamide are 42°C for a probe with is 95% to 100% homologous to the target fragment, 37°C for 90% to 95% homology, and 32°C for 85% to 90% homology. For lower homologies, formamide content should be lowered and temperature adjusted accordingly, using the equation above. If the homology between the probe and the target fragment are not known, the simplest approach is to start with both hybridization and wash conditions which are nonstringent. If non-specific bands or high background are observed after autoradiography, the filter can be washed at high stringency and reexposed. If the time required for exposure makes this approach impractical, several hybridization and/or washing stringencies should be tested in parallel.

20 Nucleic Acid Probe Assays

Methods such as PCR, branched DNA probe assays, or blotting techniques utilizing nucleic acid probes according to the invention can determine the presence of cDNA or mRNA. A probe is said to "hybridize" with a sequence of the invention if it can form a duplex or double stranded complex, which is stable enough to be detected.

25 The nucleic acid probes will hybridize to the Neisserial nucleotide sequences of the invention (including both sense and antisense strands). Though many different nucleotide sequences will encode the amino acid sequence, the native Neisserial sequence is preferred because it is the actual sequence present in cells. mRNA represents a coding sequence and so a probe should be complementary to the coding sequence; single-stranded cDNA is complementary to mRNA, and
30 so a cDNA probe should be complementary to the non-coding sequence.

The probe sequence need not be identical to the Neisserial sequence (or its complement) — some variation in the sequence and length can lead to increased assay sensitivity if the nucleic acid probe can form a duplex with target nucleotides, which can be detected. Also, the nucleic acid probe can include additional nucleotides to stabilize the formed duplex. Additional Neisserial sequence may also be helpful as a label to detect the formed duplex. For example, a non-complementary nucleotide sequence may be attached to the 5' end of the probe, with the remainder of the probe sequence being complementary to a Neisserial sequence. Alternatively, non-complementary bases or longer sequences can be interspersed into the probe, provided that the probe sequence has sufficient complementarity with the a Neisserial sequence in order to hybridize therewith and thereby form a duplex which can be detected.

The exact length and sequence of the probe will depend on the hybridization conditions, such as temperature, salt condition and the like. For example, for diagnostic applications, depending on the complexity of the analyte sequence, the nucleic acid probe typically contains at least 10-20 nucleotides, preferably 15-25, and more preferably at least 30 nucleotides, although it may be shorter than this. Short primers generally require cooler temperatures to form sufficiently stable hybrid complexes with the template.

Probes may be produced by synthetic procedures, such as the triester method of Matteucci *et al.* [*J. Am. Chem. Soc.* (1981) 103:3185], or according to Urdea *et al.* [*Proc. Natl. Acad. Sci. USA* (1983) 80: 7461], or using commercially available automated oligonucleotide synthesizers.

The chemical nature of the probe can be selected according to preference. For certain applications, DNA or RNA are appropriate. For other applications, modifications may be incorporated *eg.* backbone modifications, such as phosphorothioates or methylphosphonates, can be used to increase *in vivo* half-life, alter RNA affinity, increase nuclease resistance *etc.* [*eg.* see Agrawal & Iyer (1995) *Curr Opin Biotechnol* 6:12-19; Agrawal (1996) *TIBTECH* 14:376-387]; analogues such as peptide nucleic acids may also be used [*eg.* see Corey (1997) *TIBTECH* 15:224-229; Buchardt *et al.* (1993) *TIBTECH* 11:384-386].

Alternatively, the polymerase chain reaction (PCR) is another well-known means for detecting small amounts of target nucleic acids. The assay is described in: Mullis *et al.* [*Meth. Enzymol.* (1987) 155: 335-350]; US patents 4,683,195 and 4,683,202. Two "primer" nucleotides hybridize

with the target nucleic acids and are used to prime the reaction. The primers can comprise sequence that does not hybridize to the sequence of the amplification target (or its complement) to aid with duplex stability or, for example, to incorporate a convenient restriction site. Typically, such sequence will flank the desired Neisserial sequence.

- 5 A thermostable polymerase creates copies of target nucleic acids from the primers using the original target nucleic acids as a template. After a threshold amount of target nucleic acids are generated by the polymerase, they can be detected by more traditional methods, such as Southern blots. When using the Southern blot method, the labelled probe will hybridize to the Neisserial sequence (or its complement).
- 10 Also, mRNA or cDNA can be detected by traditional blotting techniques described in Sambrook *et al* [*supra*]. mRNA, or cDNA generated from mRNA using a polymerase enzyme, can be purified and separated using gel electrophoresis. The nucleic acids on the gel are then blotted onto a solid support, such as nitrocellulose. The solid support is exposed to a labelled probe and then washed to remove any unhybridized probe. Next, the duplexes containing the labeled probe are detected.
- 15 Typically, the probe is labelled with a radioactive moiety.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figures 1-7 show biochemical data and sequence analysis pertaining to Examples 1, 2, 3, 7, 13, 16 and 19, respectively, with ORFs 40, 38, 44, 52, 114, 41 and 124.. M1 and M2 are molecular weight markers. Arrows indicate the position of the main recombinant product or, in Western blots, the position of the main *N.meningitidis* immunoreactive band. TP indicates *N.meningitidis* total protein extract; OMV indicates *N.meningitidis* outer membrane vesicle preparation. In bactericidal assay results: a diamond (◆) shows preimmune data; a triangle (▲) shows GST control data; a circle (●) shows data with recombinant *N.meningitidis* protein. Computer analyses show a hydrophilicity plot (upper), an antigenic index plot (middle), and an AMPHI analysis (lower). The
- 20
 - 25 AMPHI program has been used to predict T-cell epitopes [Gao *et al.* (1989) *J. Immunol.* 143:3007; Roberts *et al.* (1996) *AIDS Res Hum Retrovir* 12:593; Quakyi *et al.* (1992) *Scand J Immunol* suppl.11:9) and is available in the Protean package of DNASTAR, Inc. (1228 South Park Street, Madison, Wisconsin 53715 USA).

EXAMPLES

The examples describe nucleic acid sequences which have been identified in *N.meningitidis*, along with their putative translation products. Not all of the nucleic acid sequences are complete *ie.* they encode less than the full-length wild-type protein. It is believed at present that none of the DNA
5 sequences described herein have significant homologs in *N.gonorrhoeae*.

The examples are generally in the following format:

- a nucleotide sequence which has been identified in *N.meningitidis* (strain B)
- the putative translation product of this sequence
- a computer analysis of the translation product based on database comparisons
- 10 • a corresponding gene and protein sequence identified in *N.meningitidis* (strain A)
- a description of the characteristics of the proteins which indicates that they might be suitably antigenic
- results of biochemical analysis (expression, purification, ELISA, FACS *etc.*)

The examples typically include details of sequence homology between species and strains. Proteins
15 that are similar in sequence are generally similar in both structure and function, and the homology often indicates a common evolutionary origin. Comparison with sequences of proteins of known function is widely used as a guide for the assignment of putative protein function to a new sequence and has proved particularly useful in whole-genome analyses.

Sequence comparisons were performed at NCBI (<http://www.ncbi.nlm.nih.gov>) using the
20 algorithms BLAST, BLAST2, BLASTn, BLASTp, tBLASTn, BLASTx, & tBLASTx [*eg.* see also Altschul *et al.* (1997) Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. *Nucleic Acids Research* 25:2289-3402]. Searches were performed against the following databases: non-redundant GenBank+EMBL+DDBJ+PDB sequences and non-redundant GenBank CDS translations+PDB+SwissProt+SPupdate+PIR sequences.

25 Dots within nucleotide sequences (*eg.* position 288 in Example 12) represent nucleotides which have been arbitrarily introduced in order to maintain a reading frame. In the same way, double-underlined nucleotides were removed. Lower case letters (*eg.* position 589 in Example 12) represent ambiguities which arose during alignment of independent sequencing reactions (some of

the nucleotide sequences in the examples are derived from combining the results of two or more experiments).

Nucleotide sequences were scanned in all six reading frames to predict the presence of hydrophobic domains using an algorithm based on the statistical studies of Esposti *et al.* [Critical evaluation of the hydropathy of membrane proteins (1990) *Eur J Biochem* 190:207-219]. These domains
5 represent potential transmembrane regions or hydrophobic leader sequences.

Open reading frames were predicted from fragmented nucleotide sequences using the program ORFFINDER (NCBI).

Underlined amino acid sequences indicate possible transmembrane domains or leader sequences in the ORFs, as predicted by the PSORT algorithm (<http://www.psort.nibb.ac.jp>). Functional
10 domains were also predicted using the MOTIFS program (GCG Wisconsin & PROSITE).

Various tests can be used to assess the *in vivo* immunogenicity of the proteins identified in the examples. For example, the proteins can be expressed recombinantly and used to screen patient sera by immunoblot. A positive reaction between the protein and patient serum indicates that the patient
15 has previously mounted an immune response to the protein in question *ie.* the protein is an immunogen. This method can also be used to identify immunodominant proteins.

The recombinant protein can also be conveniently used to prepare antibodies *eg.* in a mouse. These can be used for direct confirmation that a protein is located on the cell-surface. Labelled antibody (*eg.* fluorescent labelling for FACS) can be incubated with intact bacteria and the presence of label
20 on the bacterial surface confirms the location of the protein.

In particular, the following methods (A) to (S) were used to express, purify and biochemically characterise the proteins of the invention:

A) Chromosomal DNA preparation

N.meningitidis strain 2996 was grown to exponential phase in 100ml of GC medium, harvested by
25 centrifugation, and resuspended in 5ml buffer (20% Sucrose, 50mM Tris-HCl, 50mM EDTA, pH8). After 10 minutes incubation on ice, the bacteria were lysed by adding 10ml lysis solution (50mM NaCl, 1% Na-Sarkosyl, 50µg/ml Proteinase K), and the suspension was incubated at 37°C for 2

hours. Two phenol extractions (equilibrated to pH 8) and one ChCl_3 /isoamylalcohol (24:1) extraction were performed. DNA was precipitated by addition of 0.3M sodium acetate and 2 volumes ethanol, and was collected by centrifugation. The pellet was washed once with 70% ethanol and redissolved in 4ml buffer (10mM Tris-HCl, 1mM EDTA, pH 8). The DNA
5 concentration was measured by reading the OD at 260 nm.

B) Oligonucleotide design

Synthetic oligonucleotide primers were designed on the basis of the coding sequence of each ORF, using (a) the meningococcus B sequence when available, or (b) the gonococcus/meningococcus A sequence, adapted to the codon preference usage of meningococcus as necessary. Any predicted
10 signal peptides were omitted, by deducing the 5'-end amplification primer sequence immediately downstream from the predicted leader sequence.

The 5' primers included two restriction enzyme recognition sites (*Bam*HI-*Nde*I, *Bam*HI-*Nhe*I, or *Eco*RI-*Nhe*I, depending on the gene's own restriction pattern); the 3' primers included a *Xho*I restriction site. This procedure was established in order to direct the cloning of each amplification
15 product (corresponding to each ORF) into two different expression systems: pGEX-KG (using either *Bam*HI-*Xho*I or *Eco*RI-*Xho*I), and pET21b+ (using either *Nde*I-*Xho*I or *Nhe*I-*Xho*I).

5'-end primer tail: CGCGGATCCCATATG (*Bam*HI-*Nde*I)

CGCGGATCCGCTAGC (*Bam*HI-*Nhe*I)

CCGGAATTCTAGCTAGC (*Eco*RI-*Nhe*I)

20 3'-end primer tail: CCCGCTCGAG (*Xho*I)

As well as containing the restriction enzyme recognition sequences, the primers included nucleotides which hybridised to the sequence to be amplified. The number of hybridizing nucleotides depended on the melting temperature of the whole primer, and was determined for each primer using the formulae:

25 $T_m = 4 (G+C) + 2 (A+T)$ (tail excluded)

$T_m = 64.9 + 0.41 (\% \text{ GC}) - 600/N$ (whole primer)

The average melting temperature of the selected oligos were 65-70°C for the whole oligo and 50-55°C for the hybridising region alone.

Table I shows the forward and reverse primers used for each amplification. Oligos were synthesized by a Perkin Elmer 394 DNA/RNA Synthesizer, eluted from the columns in 2ml NH_4OH , and deprotected by 5 hours incubation at 56°C . The oligos were precipitated by addition of 0.3M Na-Acetate and 2 volumes ethanol. The samples were then centrifuged and the pellets resuspended in either 100 μl or 1ml of water. OD_{260} was determined using a Perkin Elmer Lambda Bio spectrophotometer and the concentration was determined and adjusted to 2-10pmol/ μl .

C) Amplification

The standard PCR protocol was as follows: 50-200ng of genomic DNA were used as a template in the presence of 20-40 μM of each oligo, 400-800 μM dNTPs solution, 1x PCR buffer (including 1.5mM MgCl_2), 2.5 units *TaqI* DNA polymerase (using Perkin-Elmer AmpliTaq, GIBCO Platinum, Pwo DNA polymerase, or Tahara Shuzo Taq polymerase).

In some cases, PCR was optimised by the addition of 10 μl DMSO or 50 μl 2M betaine.

After a hot start (adding the polymerase during a preliminary 3 minute incubation of the whole mix at 95°C), each sample underwent a double-step amplification: the first 5 cycles were performed using as the hybridization temperature the one of the oligos excluding the restriction enzymes tail, followed by 30 cycles performed according to the hybridization temperature of the whole length oligos. The cycles were followed by a final 10 minute extension step at 72°C .

The standard cycles were as follows:

	Denaturation	Hybridisation	Elongation
First 5 cycles	30 seconds 95°C	30 seconds $50-55^\circ\text{C}$	30-60 seconds 72°C
Last 30 cycles	30 seconds 95°C	30 seconds $65-70^\circ\text{C}$	30-60 seconds 72°C

The elongation time varied according to the length of the ORF to be amplified.

The amplifications were performed using either a 9600 or a 2400 Perkin Elmer GeneAmp PCR System. To check the results, 1/10 of the amplification volume was loaded onto a 1-1.5% agarose gel and the size of each amplified fragment compared with a DNA molecular weight marker.

- 5 The amplified DNA was either loaded directly on a 1% agarose gel or first precipitated with ethanol and resuspended in a suitable volume to be loaded on a 1% agarose gel. The DNA fragment corresponding to the right size band was then eluted and purified from gel, using the Qiagen Gel Extraction Kit, following the instructions of the manufacturer. The final volume of the DNA fragment was 30µl or 50µl of either water or 10mM Tris, pH 8.5.

D) Digestion of PCR fragments

- 10 The purified DNA corresponding to the amplified fragment was split into 2 aliquots and double-digested with:
- *NdeI/XhoI* or *NheI/XhoI* for cloning into pET-21b+ and further expression of the protein as a C-terminus His-tag fusion
 - *BamHI/XhoI* or *EcoRI/XhoI* for cloning into pGEX-KG and further expression of the
15 protein as N-terminus GST fusion.
 - *EcoRI/PstI*, *EcoRI/SalI*, *SalI/PstI* for cloning into pGex-His and further expression of the protein as N-terminus His-tag fusion

- 20 Each purified DNA fragment was incubated (37°C for 3 hours to overnight) with 20 units of each restriction enzyme (New England Biolabs) in a either 30 or 40µl final volume in the presence of the appropriate buffer. The digestion product was then purified using the QIAquick PCR purification kit, following the manufacturer's instructions, and eluted in a final volume of 30 or 50µl of either water or 10mM Tris-HCl, pH 8.5. The final DNA concentration was determined by 1% agarose gel electrophoresis in the presence of titrated molecular weight marker.

E) Digestion of the cloning vectors (pET22B, pGEX-KG, pTRC-His A, and pGex-His)

- 25 10µg plasmid was double-digested with 50 units of each restriction enzyme in 200µl reaction volume in the presence of appropriate buffer by overnight incubation at 37°C. After loading the

whole digestion on a 1% agarose gel, the band corresponding to the digested vector was purified from the gel using the Qiagen QIAquick Gel Extraction Kit and the DNA was eluted in 50µl of 10mM Tris-HCl, pH 8.5. The DNA concentration was evaluated by measuring OD₂₆₀ of the sample, and adjusted to 50µg/µl. 1µl of plasmid was used for each cloning procedure.

- 5 The vector pGEX-His is a modified pGEX-2T vector carrying a region encoding six histidine residues upstream to the thrombin cleavage site and containing the multiple cloning site of the vector pTRC99 (Pharmacia).

F) Cloning

- 10 The fragments corresponding to each ORF, previously digested and purified, were ligated in both pET22b and pGEX-KG. In a final volume of 20µl, a molar ratio of 3:1 fragment/vector was ligated using 0.5µl of NEB T4 DNA ligase (400 units/µl), in the presence of the buffer supplied by the manufacturer. The reaction was incubated at room temperature for 3 hours. In some experiments, ligation was performed using the Boehringer "Rapid Ligation Kit", following the manufacturer's instructions.

- 15 In order to introduce the recombinant plasmid in a suitable strain, 100µl *E. coli* DH5 competent cells were incubated with the ligase reaction solution for 40 minutes on ice, then at 37°C for 3 minutes, then, after adding 800µl LB broth, again at 37°C for 20 minutes. The cells were then centrifuged at maximum speed in an Eppendorf microfuge and resuspended in approximately 200µl of the supernatant. The suspension was then plated on LB ampicillin (100mg/ml).

- 20 The screening of the recombinant clones was performed by growing 5 randomly-chosen colonies overnight at 37°C in either 2ml (pGEX or pTC clones) or 5ml (pET clones) LB broth + 100µg/ml ampicillin. The cells were then pelleted and the DNA extracted using the Qiagen QIAprep Spin Miniprep Kit, following the manufacturer's instructions, to a final volume of 30µl. 5µl of each individual miniprep (approximately 1g) were digested with either *NdeI/XhoI* or *BamHI/XhoI* and the whole digestion loaded onto a 1-1.5% agarose gel (depending on the expected insert size), in parallel with the molecular weight marker (1Kb DNA Ladder, GIBCO). The screening of the positive clones was made on the base of the correct insert size.
- 25

G) Expression

Each ORF cloned into the expression vector was transformed into the strain suitable for expression of the recombinant protein product. 1µl of each construct was used to transform 30µl of *E.coli* BL21 (pGEX vector), *E.coli* TOP 10 (pTRC vector) or *E.coli* BL21-DE3 (pET vector), as described above. In the case of the pGEX-His vector, the same *E.coli* strain (W3110) was used for initial cloning and expression. Single recombinant colonies were inoculated into 2ml LB+Amp (100µg/ml), incubated at 37°C overnight, then diluted 1:30 in 20ml of LB+Amp (100µg/ml) in 100ml flasks, making sure that the OD₆₀₀ ranged between 0.1 and 0.15. The flasks were incubated at 30°C into gyratory water bath shakers until OD indicated exponential growth suitable for induction of expression (0.4-0.8 OD for pET and pTRC vectors; 0.8-1 OD for pGEX and pGEX-His vectors). For the pET, pTRC and pGEX-His vectors, the protein expression was induced by addition of 1mM IPTG, whereas in the case of pGEX system the final concentration of IPTG was 0.2mM. After 3 hours incubation at 30°C, the final concentration of the sample was checked by OD. In order to check expression, 1ml of each sample was removed, centrifuged in a microfuge, the pellet resuspended in PBS, and analysed by 12% SDS-PAGE with Coomassie Blue staining. The whole sample was centrifuged at 6000g and the pellet resuspended in PBS for further use.

H) GST-fusion proteins large-scale purification.

A single colony was grown overnight at 37°C on LB+Amp agar plate. The bacteria were inoculated into 20ml of LB+Amp liquid culture in a water bath shaker and grown overnight. Bacteria were diluted 1:30 into 600ml of fresh medium and allowed to grow at the optimal temperature (20-37°C) to OD₅₅₀ 0.8-1. Protein expression was induced with 0.2mM IPTG followed by three hours incubation. The culture was centrifuged at 8000rpm at 4°C. The supernatant was discarded and the bacterial pellet was resuspended in 7.5ml cold PBS. The cells were disrupted by sonication on ice for 30 sec at 40W using a Branson sonifier B-15, frozen and thawed twice and centrifuged again. The supernatant was collected and mixed with 150µl Glutathione-Sepharose 4B resin (Pharmacia) (previously washed with PBS) and incubated at room temperature for 30 minutes. The sample was centrifuged at 700g for 5 minutes at 4°C. The resin was washed twice with 10ml cold PBS for 10 minutes, resuspended in 1ml cold PBS, and loaded on a disposable column. The resin was washed twice with 2ml cold PBS until the flow-through reached OD₂₈₀ of 0.02-0.06. The GST-fusion protein was eluted by addition of 700µl cold Glutathione elution buffer (10mM reduced

glutathione, 50mM Tris-HCl) and fractions collected until the OD₂₈₀ was 0.1. 21µl of each fraction were loaded on a 12% SDS gel using either Biorad SDS-PAGE Molecular weight standard broad range (M1) (200, 116.25, 97.4, 66.2, 45, 31, 21.5, 14.4, 6.5 kDa) or Amersham Rainbow Marker (M2) (220, 66, 46, 30, 21.5, 14.3 kDa) as standards. As the MW of GST is 26kDa, this value must
5 be added to the MW of each GST-fusion protein.

I) His-fusion solubility analysis

To analyse the solubility of the His-fusion expression products, pellets of 3ml cultures were resuspended in buffer M1 [500µl PBS pH 7.2]. 25µl lysozyme (10mg/ml) was added and the bacteria were incubated for 15 min at 4°C. The pellets were sonicated for 30 sec at 40W using a
10 Branson sonifier B-15, frozen and thawed twice and then separated again into pellet and supernatant by a centrifugation step. The supernatant was collected and the pellet was resuspended in buffer M2 [8M urea, 0.5M NaCl, 20mM imidazole and 0.1M NaH₂PO₄] and incubated for 3 to 4 hours at 4°C. After centrifugation, the supernatant was collected and the pellet was resuspended in buffer M3 [6M guanidinium-HCl, 0.5M NaCl, 20mM imidazole and 0.1M NaH₂PO₄] overnight
15 at 4°C. The supernatants from all steps were analysed by SDS-PAGE.

J) His-fusion large-scale purification.

A single colony was grown overnight at 37°C on a LB + Amp agar plate. The bacteria were inoculated into 20ml of LB+Amp liquid culture and incubated overnight in a water bath shaker. Bacteria were diluted 1:30 into 600ml fresh medium and allowed to grow at the optimal
20 temperature (20-37°C) to OD₅₅₀ 0.6-0.8. Protein expression was induced by addition of 1mM IPTG and the culture further incubated for three hours. The culture was centrifuged at 8000rpm at 4°C, the supernatant was discarded and the bacterial pellet was resuspended in 7.5ml of either (i) cold buffer A (300mM NaCl, 50mM phosphate buffer, 10mM imidazole, pH 8) for soluble proteins or (ii) buffer B (urea 8M, 10mM Tris-HCl, 100mM phosphate buffer, pH 8.8) for insoluble proteins.

25 The cells were disrupted by sonication on ice for 30 sec at 40W using a Branson sonifier B-15, frozen and thawed two times and centrifuged again.

For insoluble proteins, the supernatant was stored at -20°C, while the pellets were resuspended in 2ml buffer C (6M guanidine hydrochloride, 100mM phosphate buffer, 10mM Tris-HCl, pH 7.5) and treated in a homogenizer for 10 cycles. The product was centrifuged at 13000rpm for 40 minutes.

- Supernatants were collected and mixed with 150µl Ni²⁺-resin (Pharmacia) (previously washed with either buffer A or buffer B, as appropriate) and incubated at room temperature with gentle agitation for 30 minutes. The sample was centrifuged at 700g for 5 minutes at 4°C. The resin was washed twice with 10ml buffer A or B for 10 minutes, resuspended in 1ml buffer A or B and loaded on a disposable column. The resin was washed at either (i) 4°C with 2ml cold buffer A or (ii) room temperature with 2ml buffer B, until the flow-through reached OD₂₈₀ of 0.02-0.06.
- 10 The resin was washed with either (i) 2ml cold 20mM imidazole buffer (300mM NaCl, 50mM phosphate buffer, 20mM imidazole, pH 8) or (ii) buffer D (urea 8M, 10mM Tris-HCl, 100mM phosphate buffer, pH 6.3) until the flow-through reached the O.D₂₈₀ of 0.02-0.06. The His-fusion protein was eluted by addition of 700µl of either (i) cold elution buffer A (300mM NaCl, 50mM phosphate buffer, 250mM imidazole, pH 8) or (ii) elution buffer B (urea 8M, 10mM Tris-HCl, 100mM phosphate buffer, pH 4.5) and fractions collected until the O.D₂₈₀ was 0.1. 21µl of each fraction were loaded on a 12% SDS gel.

K) His-fusion proteins renaturation

- 10% glycerol was added to the denatured proteins. The proteins were then diluted to 20µg/ml using dialysis buffer I (10% glycerol, 0.5M arginine, 50mM phosphate buffer, 5mM reduced glutathione, 0.5mM oxidised glutathione, 2M urea, pH 8.8) and dialysed against the same buffer at 4°C for 12-14 hours. The protein was further dialysed against dialysis buffer II (10% glycerol, 0.5M arginine, 50mM phosphate buffer, 5mM reduced glutathione, 0.5mM oxidised glutathione, pH 8.8) for 12-14 hours at 4°C. Protein concentration was evaluated using the formula:

$$\text{Protein (mg/ml)} = (1.55 \times \text{OD}_{280}) - (0.76 \times \text{OD}_{260})$$

25 L) His-fusion large-scale purification

500ml of bacterial cultures were induced and the fusion proteins were obtained soluble in buffer M1, M2 or M3 using the procedure described above. The crude extract of the bacteria was loaded

- onto a Ni-NTA superflow column (Qiagen) equilibrated with buffer M1, M2 or M3 depending on the solubilization buffer of the fusion proteins. Unbound material was eluted by washing the column with the same buffer. The specific protein was eluted with the corresponding buffer containing 500mM imidazole and dialysed against the corresponding buffer without imidazole.
- 5 After each run the columns were sanitized by washing with at least two column volumes of 0.5 M sodium hydroxide and reequilibrated before the next use.

M) Mice immunisations

- 20µg of each purified protein were used to immunise mice intraperitoneally. In the case of ORF 44, CD1 mice were immunised with Al(OH)₃ as adjuvant on days 1, 21 and 42, and immune response
- 10 was monitored in samples taken on day 56. For ORF 40, CD1 mice were immunised using Freund's adjuvant, rather than Al(OH)₃, and the same immunisation protocol was used, except that the immune response was measured on day 42, rather than 56. Similarly, for ORF 38, CD1 mice were immunised with Freund's adjuvant, but the immune response was measured on day 49.

N) ELISA assay (sera analysis)

- 15 The acapsulated MenB M7 strain was plated on chocolate agar plates and incubated overnight at 37°C. Bacterial colonies were collected from the agar plates using a sterile dracon swab and inoculated into 7ml of Mueller-Hinton Broth (Difco) containing 0.25% Glucose. Bacterial growth was monitored every 30 minutes by following OD₆₂₀. The bacteria were let to grow until the OD reached the value of 0.3-0.4. The culture was centrifuged for 10 minutes at 10000rpm. The
- 20 supernatant was discarded and bacteria were washed once with PBS, resuspended in PBS containing 0.025% formaldehyde, and incubated for 2 hours at room temperature and then overnight at 4°C with stirring. 100µl bacterial cells were added to each well of a 96 well Greiner plate and incubated overnight at 4°C. The wells were then washed three times with PBT washing buffer (0.1% Tween-20 in PBS). 200µl of saturation buffer (2.7% Polyvinylpyrrolidone 10 in
- 25 water) was added to each well and the plates incubated for 2 hours at 37°C. Wells were washed three times with PBT. 200µl of diluted sera (Dilution buffer: 1% BSA, 0.1% Tween-20, 0.1% NaN₃ in PBS) were added to each well and the plates incubated for 90 minutes at 37°C. Wells were washed three times with PBT. 100µl of HRP-conjugated rabbit anti-mouse (Dako) serum diluted 1:2000 in dilution buffer were added to each well and the plates were incubated for 90 minutes at

37°C. Wells were washed three times with PBT buffer. 100µl of substrate buffer for HRP (25ml of citrate buffer pH5, 10mg of O-phenildiamine and 10µl of H₂O) were added to each well and the plates were left at room temperature for 20 minutes. 100µl H₂SO₄ was added to each well and OD₄₉₀ was followed. The ELISA was considered positive when OD₄₉₀ was 2.5 times the respective pre-immune sera.

O) FACScan bacteria Binding Assay procedure.

The acapsulated MenB M7 strain was plated on chocolate agar plates and incubated overnight at 37°C. Bacterial colonies were collected from the agar plates using a sterile dracon swab and inoculated into 4 tubes containing 8ml each Mueller-Hinton Broth (Difco) containing 0.25% glucose. Bacterial growth was monitored every 30 minutes by following OD₆₂₀. The bacteria were let to grow until the OD reached the value of 0.35-0.5. The culture was centrifuged for 10 minutes at 4000rpm. The supernatant was discarded and the pellet was resuspended in blocking buffer (1% BSA, 0.4% NaN₃) and centrifuged for 5 minutes at 4000rpm. Cells were resuspended in blocking buffer to reach OD₆₂₀ of 0.07. 100µl bacterial cells were added to each well of a Costar 96 well plate. 100µl of diluted (1:200) sera (in blocking buffer) were added to each well and plates incubated for 2 hours at 4°C. Cells were centrifuged for 5 minutes at 4000rpm, the supernatant aspirated and cells washed by addition of 200µl/well of blocking buffer in each well. 100µl of R-Phicoerytrin conjugated F(ab)₂ goat anti-mouse, diluted 1:100, was added to each well and plates incubated for 1 hour at 4°C. Cells were spun down by centrifugation at 4000rpm for 5 minutes and washed by addition of 200µl/well of blocking buffer. The supernatant was aspirated and cells resuspended in 200µl/well of PBS, 0.25% formaldehyde. Samples were transferred to FACScan tubes and read. The condition for FACScan setting were: FL1 on, FL2 and FL3 off; FSC-H threshold:92; FSC PMT Voltage: E 02; SSC PMT: 474; Amp. Gains 7.1; FL-2 PMT: 539; compensation values: 0.

25 P) OMV preparations

Bacteria were grown overnight on 5 GC plates, harvested with a loop and resuspended in 10 ml 20mM Tris-HCl. Heat inactivation was performed at 56°C for 30 minutes and the bacteria disrupted by sonication for 10 minutes on ice (50% duty cycle, 50% output). Unbroken cells were removed by centrifugation at 5000g for 10 minutes and the total cell envelope fraction recovered by centrifugation

at 50000g at 4°C for 75 minutes. To extract cytoplasmic membrane proteins from the crude outer membranes, the whole fraction was resuspended in 2% sarkosyl (Sigma) and incubated at room temperature for 20 minutes. The suspension was centrifuged at 10000g for 10 minutes to remove aggregates, and the supernatant further ultracentrifuged at 50000g for 75 minutes to pellet the outer
5 membranes. The outer membranes were resuspended in 10mM Tris-HCl, pH8 and the protein concentration measured by the Bio-Rad Protein assay, using BSA as a standard.

Q) Whole Extracts preparation

Bacteria were grown overnight on a GC plate, harvested with a loop and resuspended in 1ml of 20mM Tris-HCl. Heat inactivation was performed at 56°C for 30 minutes.

10 R) Western blotting

Purified proteins (500ng/lane), outer membrane vesicles (5µg) and total cell extracts (25µg) derived from MenB strain 2996 were loaded on 15% SDS-PAGE and transferred to a nitrocellulose membrane. The transfer was performed for 2 hours at 150mA at 4°C, in transferring buffer (0.3 % Tris base, 1.44 % glycine, 20% methanol). The membrane was saturated by overnight incubation
15 at 4°C in saturation buffer (10% skimmed milk, 0.1% Triton X100 in PBS). The membrane was washed twice with washing buffer (3% skimmed milk, 0.1% Triton X100 in PBS) and incubated for 2 hours at 37°C with mice sera diluted 1:200 in washing buffer. The membrane was washed twice and incubated for 90 minutes with a 1:2000 dilution of horseradish peroxidase labelled anti-mouse Ig. The membrane was washed twice with 0.1% Triton X100 in PBS and developed with
20 the Opti-4CN Substrate Kit (Bio-Rad). The reaction was stopped by adding water.

S) Bactericidal assay

MC58 strain was grown overnight at 37°C on chocolate agar plates. 5-7 colonies were collected and used to inoculate 7ml Mueller-Hinton broth. The suspension was incubated at 37°C on a nutator and let to grow until OD₆₂₀ was 0.5-0.8. The culture was aliquoted into sterile 1.5ml Eppendorf
25 tubes and centrifuged for 20 minutes at maximum speed in a microfuge. The pellet was washed once in Gey's buffer (Gibco) and resuspended in the same buffer to an OD₆₂₀ of 0.5, diluted 1:20000 in Gey's buffer and stored at 25°C.

50µl of Gey's buffer/1% BSA was added to each well of a 96-well tissue culture plate. 25µl of diluted mice sera (1:100 in Gey's buffer/0.2% BSA) were added to each well and the plate incubated at 4°C. 25µl of the previously described bacterial suspension were added to each well. 25µl of either heat-inactivated (56°C waterbath for 30 minutes) or normal baby rabbit complement were added to each well. Immediately after the addition of the baby rabbit complement, 22µl of each sample/well were plated on Mueller-Hinton agar plates (time 0). The 96-well plate was incubated for 1 hour at 37°C with rotation and then 22µl of each sample/well were plated on Mueller-Hinton agar plates (time 1). After overnight incubation the colonies corresponding to time 0 and time 1 hour were counted.

10 **Table II** gives a summary of the cloning, expression and purification results.

Example 1

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 1>:

```

1  ..ACACTGTTGT TTGCAACGGT TCAGGCAAGT GCTAACCAAT GAAGAGCAAG
51  AAGAAGATTT ATATTTAGAC CCCGTACAAC GCACTGTTGC CGTGTGTGATA
15  101  GTCAATTCCG ATAAAGAAGG CACGGGAGAA AAAGAAAAAG TAGAAGAAAA
151  TTCAGATTGG GCAGTATATT TCAACGAGAA AGGAGTACTA ACAGCCAGAG
201  AAATCACCyT CAAAGCCGGC GACAACCTGA AAATCAAACA AAACGGCACA
251  AACTTCACCT ACTCGCTGAA AAAAGACCTC ACAGATCTGA CCAGTGTGG
20  301  AACTGAAAAA TTATCGTTTA GCGCAAACGG CAATAAAGTC AACATcACAA
351  GCGACACCAA AGGCTTGAAT TTGCGAAAG AAACGGCTGG sACGAACGgC
401  GACACCACGG TTCATCTGAA CGGTATTGGT TCGACTTTGA CCGATACGCT
451  GCTGAATACC GGAGCGACCA CAAACGTAAC CAACGACAAC GTTACCGATG
501  ACGAGAAAAA ACGTGCGGCA AGCGTTAAAG ACGTATTAAA CGCTGGCTGG
551  AACATTAAAG GCGTTAAACC CGGTACAACA GCTTCCGATA ACGTTGATTT
25  601  CGTCCGCACT TACGACACAG TCGAGTTCTT GAGCGCAGAT ACGAAAAACAA
651  CGACTGTAA TGTGAAAGC AAAGACAACG GCAAGAAAAC CGAAGTTAA
701  ATCGGTGCGA AGACTTCTGT TATTAAAGAA AAAGAC...
```

This corresponds to the amino acid sequence <SEQ ID 2; ORF40>:

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1  ..TLFATVQAS ANQEEQEDL YLDPVORTVA VLIVNSDKEG TGEKEKVEEN
30  51  SDWAVYFNEK GVLTAAREITX KAGDNLKIQ NGTNFTYSLK KDLTDLTSVG
101  TEKLSFSANG NKNVITSDTK GLNFAKETAG TNGDTPVHLN GIGSTLTDTL
151  LNTGATTNVT NDNVTDDEKK RAASVKDVLN AGWNIKGVKP GTTASDNVDF
201  VRTYDTVEFL SADTKTTTVN VESKDNGKKT EVKIGAKTSV IKEKD...
```

Further work revealed the complete DNA sequence <SEQ ID 3>:

```

35  1  ATGAACAAAA TATACCGCAT CATTGGAAT AGTGCCCTCA ATGCCTGGGT
51  CGTCGTATCC GAGCTCACAC GCAACCACAC CAAACGCGCC TCCGCAACCG
101  TGAAGACCGC CGTATTGGCG AACTGTTGT TTGCAACGGT TCAGGCAAGT
151  GCTAACAAATG AAGAGCAAGA AGAAGATTTA TATTTAGACC CCGTACAACG
201  CACTGTTGCC GTGTTGATAG TCAATCCGA TAAAGAAGGC ACGGGAGAAA
40  251  AAGAAAAAGT AGAAGAAAAAT TCAGATTGGG CAGTATATT CAACGAGAAA
301  GGAGTACTAA CAGCCAGAGA AATCACCCTC AAAGCCGGCG ACAACCTGAA
351  AATCAAACAA AACGGCACAA ACTTCACCTA CTCGCTGAAA AAAGACCTCA
401  CAGATCTGAC CAGTGTGGA ACTGAAAAAT TATCGTTTAG CGCAAACGGC
45  451  AATAAAGTCA ACATCACAAAG CGACACCAA GGCTTGAATT TTGCGAAAGA
501  AACGGCTGGG ACGAACGGCG ACACCACGGT TCATCTGAAC GGTATTGGTT
551  CGACTTTGAC CGATACGCTG CTGAATACCG GAGCGACCAC AAACGTAACC
601  AACGACAACG TTACCGATGA CGAGAAAAAA CGTGCGGCAA GCGTTAAAGA
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5
10
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20

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651 CGTATTAAAC GCTGGCTGGA ACATTAAAGG CGTTAAACCC GGTACAACAG
701 CTTCCGATAA CGTTGATTTC GTCCGCACTT ACGACACAGT CGAGTTCTTG
751 AGCGCAGATA CGAAAACAAC GACTGTTAAT GTGGAAGCA AAGACAACGG
801 CAAGAAAACC GAAGTTAAAA TCGGTGCGAA GACTTCTGTT ATTAAAGAAA
851 AAGACGGTAA GTTGTTACT GGTAAAGACA AAGGCGAGAA TGGTCTTCT
901 ACAGACGAAG GCGAAGGCTT AGTGACTGCA AAAGAAGTGA TTGATGCAGT
951 AAACAAGGCT GGTGGAGAA TGAACAAC AACCGCTAAT GGTCAAACAG
1001 GTCAAGCTGA CAAGTTTGAA ACCGTTACAT CAGGCACAAA TGTAACCTTT
1051 GCTAGTGGTA AAGGTACAAC TGCGACTGTA AGTAAAGATG ATCAAGGCAA
1101 CATCACTGTT ATGTATGATG TAAATGTCGG CGATGCCCTA AACGTCAATC
1151 AGCTGCAAAA CAGCGGTTGG AATTGGATT CCAAAGCGGT TGCAGGTTCT
1201 TCGGGCAAAG TCATCAGCGG CAATGTTTCG CCGAGCAAGG GAAAGATGGA
1251 TGAAACCGTC AACATTAATG CCGCAACAA CATCGAGATT ACCCGCAACG
1301 GTAAAAATAT CGACATCGCC ACTTCGATGA CCCCAGCTT TTCCAGCGTT
1351 TCGCTCGGCG CGGGGGCGGA TCGCCCACT TTGAGCGTGG ATGGGGACGC
1401 ATTGAATGTC GGCAGCAAGA AGGACAACAA ACCCGTCCGC ATTACCAATG
1451 TCGCCCCGGG CGTTAAAGAG GGGGATGTTA CAAACGTCGC ACAACTTAAA
1501 GCGGTGGGCG AAAACTTGAA CAACCGCATC GACAATGTGG ACGGCAACGC
1551 GCGTGGGCGG ATCGCCCAAG CGATTGCAAC CGCAGGTCGT GTTCAGGCGT
1601 ATTTGCCCGG CAAGAGTATG ATGGCGATCG GCGGCGGCAC TTATCGCGGC
1651 GAAGCCGGTT ACGCCATCGG CTACTCCAGT ATTTCCGACG GCGGAAATTG
1701 GATTATCAAA GGCACGGCTT CCGCAATTC GCGGCGCAT TTCCGGTGCTT
1751 CCGCATCTGT CGGTTATCAG TGGTAA

```

This corresponds to the amino acid sequence <SEQ ID 4; ORF40-1>:

25
30
35

```

1 MNKIYRIWN SALNAWVVVS ELTRNHTKRA SATVKTAFLA TLLFATVQAS
51 ANNEEQEEDL YLDPVQRTVA VLI VNSDKEG TGEKEKVEEN SDWAVYFNEK
101 GVLTAAREITL KAGDNLKIKQ NGTNFTYSLK KDLTDLTSVG TEKLSFSANG
151 NKNVITSDTK GLNFAKETAG TNGDTTVHLN GIGSTLTDLT LNTGATTNVT
201 NONVTDDEKK RAASVKDVLN AGWNIKGVKP GTTASDNVDF VRTYDTVEFL
251 SADTKTTTVN VESKDNKGKT EVKIGAKTSV I KEKDGKLV T GKDKGENGSS
301 TDEGEGLVTA KEVIDAVNKA GWRMKT TAN GGTGQADKFE TVTSGTNVTF
351 ASGKGTTATV SKDDQGNITV MYDVNVGDAL NVNQLQNSGW NLDSKAVAGS
401 SGKVISGNVS PSKGKMDTV NINAGNNIEI TRNGKNIDIA TSMTPOFSSV
451 SLGAGADAPT LSVGDALNV GSKKDNKPV ITNVAPGVKE GDVTNVAQLK
501 GVAQNLNNRI DNV DGNARAG IAQAIATAGL VQAYLPKSM MAIGGGTYRG
551 EAGYAIGYSS ISDGGNWI K GTASGNSRGH FGASASVGYQ W*

```

Further work identified the corresponding gene in strain A of *N.meningitidis* <SEQ ID 5 >:

40
45
50
55
60
65

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1 ATGAACAAAA TATACCGCAT CATTTGGAAT AGTGCCCTCA ATGCCTGNGT
51 CGCCGTATCC GAGCTCACAC GCAACCACAC CAAACCGGCC TCCGCAACCG
101 TGAAGACCGC CGTATTGGCG ACACGTGTTG TTGCAACGGT TCAGGCGAAT
151 GCTACCGATG AAGATGAAGA AGAAGAGTTA GAATCCGTAC AACGCTCTGT
201 CGTAGGGAGC ATTCAAGCCA GTATGGAAGG CAGCGGCGAA TTGGAACGA
251 TATCATTATC AATGACTAAC GACAGCAAGG AATTTGTAGA CCCATACATA
301 GTAGTTACCC TCAAAGCCGG CGACAACCTG AAAATCAAAC AAAACACCAA
351 TGAAAACACC AATGCCAGTA GCTTCACCTA CTCGCTGAAA AAAGACCTCA
401 CAGGCCTGAT CAATGTTGAN ACTGAAAAAT TATCGTTTGG CGCAAACGGC
451 AAGAAAGTCA ACATCATAAG CGACACCAAA GGCTTGAATT TCGCGAAAGA
501 AACGGCTGGG ACGAACGGCG ACACCACGGT TCATCTGAAC GGTATCGGTT
551 CGACTTTGAC CGATACGCTT GCGGGTCTT CTGCTTCTCA CGTTGATGCG
601 GGTAACCNAA GTACACATTA CACTCGTGCA GCAAGTATTA AGGATGTGTT
651 GAATGCGGGT TGAATATTA AGGGTGTTAA ANNNGGCTCA ACACTGGTC
701 AATCAGAAAA TGTGATTTT GTCCGCACTT ACGACACAGT CGAGTTCTTG
751 AGCGCAGATA CGNAAACAAC GACNGTTAAT GTGGAAGCA AAGACAACGG
801 CAAGAGAACC GAAGTTAAAA TCGGTGCGAA GACTTCTGTT ATTAAAGAAA
851 AAGACGGTAA GTTGTTACT GGTAAAGGCA AAGGCGAGAA TGGTCTTCT
901 ACAGACGAAG GCGAAGGCTT AGTGACTGCA AAAGAAGTGA TTGATGCAGT
951 AAACAAGGCT GGTGGAGAA TGAACAAC AACCGCTAAT GGTCAAACAG
1001 GTCAAGCTGA CAAGTTTGAA ACCGTTACAT CAGGCACAAA TGTAACCTTT
1051 GCTAGTGGTA AAGGTACAAC TGCGACTGTA AGTAAAGATG ATCAAGGCAA
1101 CATCACTGTT ATGTATGATG TAAATGTCGG CGATGCCCTA AACGTCAATC
1151 AGCTGCAAAA CAGCGGTTGG AATTGGATT CCAAAGCGGT TGCAGGTTCT
1201 TCGGGCAAAG TCATCAGCGG CAATGTTTCG CCGAGCAAGG GAAAGATGGA
1251 TGAAACCGTC AACATTAATG CCGCAACAA CATCGAGATT AGCCGCAACG
1301 GTAAAAATAT CGACATCGCC ACTTCGATGG CGCCGCACTT TTCCAGCGTT
1351 TCGCTCGGCG CGGGGGCAGA TCGCCCACT TTAAGCGTGG ATGACGAGGG
1401 CCGGTTGAAT GTCGGCAGCA AGGATGCCAA CAAACCCGTC CGCATTACCA

```

5
1451 ATGTCGCCCC GGGCGTTAAA GANGGGGATG TTACAAACGT CNCACAACTT
1501 AAAGGCGTGG CGCAAAACTT GAACAACCGC ATCGACAATG TGGACGGCAA
1551 CGCGCGTGCN GGCATCGCCC AAGCGATTGC AACCGCAGGT CTGGTTCAGG
1601 CGTATCTGCC CGGCAAGAGT ATGATGGCGA TCGGCGGCGG CACTTATCGC
1651 GCGGAAGCCG GTTACGCCAT CGGCTACTCC AGTATTTCG ACGGCGGAAA
1701 TTGGATTATC AAAGGCACGG CTTCCGGCAA TTCGCGCGGC CATTTCGGTG
1751 CTTCCGCATC TGTCGGTTAT CAGTGGTAA

This encodes a protein having amino acid sequence <SEQ ID 6; ORF40a>:

10
1 MNKIYRIWN SALNAXVAVS ELTRNHTKRA SATVKTAVLA TLLFATVQAN
51 ATDEDEEEEL ESVQSVVGS IQASMEGSGE LETISLSMTN DSKEFVDPYI
101 VVTLKAGDNL KIKQNTNENT NASSFTYSLK KDLTGILNVX TEKLSFGANG
151 KKVNIISDTK GLNFAKETAG TNGDITVHLN GIGSTLTDTL AGSSASHVDA
201 GNXSTHYTRA ASIKDVLNAG WNIKGVKXGS TTGQSENVDF VRTYDTVEFL
251 SADTXXTTVN VESKDNGKRT EVKIGAKTSV IKEKDGLVLT GKGKGENGSS
15 301 TDEGEGLVTA KEVIDAVNKA GWRMKTITAN GQTGQADKFE TVTSGTNVTF
351 ASGKGTTATV SKDDQGNITV MYDVNVGDAL NVNQLQNSGW NLDSKAVAGS
401 SGKVISGNVS PSKGKMDETV NINAGNNIEI SRNGKNIDIA TSMAPQFSSV
451 SLGAGADAPT LSVDDGALN VSKDANKPV RITNVAPGVK XGDVTNVXQL
501 KGVAQNLLNR IDNVDDGNARA GIAQAIATAG LVQAYLPKGS MMAIGGGTYR
20 551 GEAGYAIGYS SISDGGNWII KGTASGNSRG HFGASASVGY QW*

The originally-identified partial strain B sequence (ORF40) shows 65.7% identity over a 254aa overlap with ORF40a:

25
orf40.pep TLLFATVQASANQEEQEEEDLYDPVQRTVA
orf40a SALNAXVAVSELTRNHTKRASATVKTAVLATLLFATVQANATDEDEEEEL--ESVQSV-
20 30 40 50 60
30
orf40.pep VLVNSDKEGTGEKEKVEEN--SDWAVYFNEKGVLTAREITXKAGDNLKIKQN-----GT
orf40a VLSIQASMEGSGELETISLSMTNDSKEFVDPYIV----VTLKAGDNLKIKQNTNENTNAS
70 80 90 100 110 120
35
orf40.pep NFTYSLKKDLTDLTSVGTEKLSFSGANGKNVITS DTKGLNFAKETAGTNGDITVHLNGIG
orf40a SFTYSLKKDLTGLINNVXTEKLSFGANGKKNVITS DTKGLNFAKETAGTNGDITVHLNGIG
130 140 150 160 170 180
40
orf40.pep STLTDTLLNTGATTNVTNDNVT DDEKKRAASVKDVLNAGWNIKGVPKGTTA--SDNVDFV
orf40a STLTDTLAGSSAS-HVDAGNXST-HYTRAASIKDVLNAGWNIKGVKXGSTTGQSENVDFV
190 200 210 220 230 240
45
orf40.pep RTYDTVEFLSADTKTTTVNVESKDNGKKTEVKIGAKTSVIKEKD
orf40a RTYDTVEFLSADTKTTTVNVESKDNGKRTEVKIGAKTSVIKEKDGKLVLTGKGKGENGSSST
250 260 270 280 290 300

The complete strain B sequence (ORF40-1) and ORF40a show 83.7% identity in 601 aa overlap:

55
orf40-1.pep MNKIYRIIWN SALNAXVAVSELTRNHTKRASATVKTAVLATLLFATVQASANNEEQEEDL
orf40a MNKIYRIIWN SALNAXVAVSELTRNHTKRASATVKTAVLATLLFATVQANATDEDEEEEL
10 20 30 40 50 60
60
orf40-1.pep YLDPVQRTVAVLVNSDKEGTGEKEKVEEN--SDWAVYFNEKGVLTAREITLXKAGDNLKIK
orf40a YLDPVQRTVAVLVNSDKEGTGEKEKVEEN--SDWAVYFNEKGVLTAREITLXKAGDNLKIK
70 80 90 100 110 119

55 Computer analysis of these amino acid sequences gave the following results:

Homology with Hsf protein encoded by the type b surface fibrils locus of *H.influenzae*
(accession number U41852)

ORF40 and Hsf protein show 54% aa identity in 251 aa overlap:

60	Orf40	1	TLLFATVQASANQEEQEEDLYLDPVQRTVAVLIVNSDXXXXXXXXXXXXXNSDWAYVFNEK	60
			TLLFATVQA+A E++E LDPV RT VL +SD NS+W +YF+ K	
	Hsf	41	TLLFATVQANATDEDEE----LDPVVRTAPVLSFHSQKEGTGEKEVTE-NSNWGIYFDNK	95
65	Orf40	61	GVLTAIREITXKAGDNLKIKQN-----GTNFTYSLKKDLTDLTSVGTKEKLSFSANGNKVN	114
			GVL A IT KAGDNLKIKQN ++FTYSLKKDLTDLTSV TEKLSF ANG+KV+	
	Hsf	96	GVLKAGAITLKAGDNLKIKQNTDESTNASSFTYSLKKDLTDLTSVATEKLSFGANGDKVD	155

5 Orf40 115 ITSDTKGLNFAKETAGTNGDTTVHLNGIGSTLTDTLLNTGAXXXXXXXXXXXXXEKKRAAS 174
 ITSD GL AK G+ VHLNG+ STL D + NTG EK RAA+
 Hsf 156 ITSDANGLKLAK-----TGNGNVHLNGLDSTLPDAVTNTGVLSSSSFTPNV-EKTRAAT 209
 Orf40 175 VKDVLNAGWNIKGVPKPGTTASDNVDFVRTYDTVEFLSADTKTTTVNVESKDNKKTEVKI 234
 VKDVLNAGWNIKG K ++VD V Y+ VEF++ D T V + +K+NGK TEVK
 Hsf 210 VKDVLNAGWNIKGAKTAGGNVESVDLVSAYNNEFITGDKNTLDVVLTAKENGKTTEVKF 269
 10 Orf40 235 GAKTSVIKEKD 245
 KTSVIKEKD
 Hsf 270 TPKTSVIKEKD 280

ORF40a also shows homology to Hsf:

15 gill666683 (U41852) hsf gene product [Haemophilus influenzae] Length = 2353
 Score = 153 (67.7 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 33/36 (91%), Positives = 34/36 (94%)
 Query: 16 VAVSELTRNHTKRASATVKTAVLATLLFATVQANAT 51
 V VSELTR HTKRASATV+TAVLATLLFATVQANAT
 20 Sbjct: 17 VVVSELTRTHTKRASATVETAVLATLLFATVQANAT 52
 Score = 161 (71.2 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 32/38 (84%), Positives = 36/38 (94%)
 25 Query: 101 VTLKAGDNLKIKQNTNENTNASSFTYSLKKDLTG LINV 138
 +TLKAGDNLKIKQNT+E+TNASSFTYSLKKDLT L +V
 Sbjct: 103 ITLKAGDNLKIKQNTDESTNASSFTYSLKKDLTDLTSV 140
 Score = 110 (48.7 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 21/29 (72%), Positives = 25/29 (86%)
 30 Query: 138 VTEKLSFGANGKKVNIISDTKGLNFAKET 166
 V++KLS G NG KVNI SDTKGLNFAK++
 Sbjct: 1439 VSDKLSLGTNGNKVNITSDTKGLNFAKDS 1467
 35 Score = 85 (37.6 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 18/32 (56%), Positives = 20/32 (62%)
 40 Query: 169 TNGDTTVHLNGIGSTLTDTLAGSSASHVDAGN 200
 T D +HLNGI STLTDTL S A+ GN
 Sbjct: 1469 TGDDANIHLNGIASTLTDTLLNSGATTNLGGN 1500
 Score = 92 (40.7 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 16/19 (84%), Positives = 19/19 (100%)
 45 Query: 206 RAASIKDVLNAGWNIKGVK 224
 RAAS+KDVLNAGWN++GVK
 Sbjct: 1509 RAASVKDVLNAGWNVRGVK 1527
 50 Score = 90 (39.8 bits), Expect = 1.5e-116, Sum P(11) = 1.5e-116
 Identities = 17/28 (60%), Positives = 20/28 (71%)
 55 Query: 226 STTGQSENVDFVRTYDTVEFLSADTTT 253
 S Q EN+DFV TYDTV+F+S D TT
 Sbjct: 1530 SANNQVENIDFVATYDTVDFVSGDKDTT 1557

Based on homology with Hsf, it was predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

ORF40-1 (61kDa) was cloned in pET and pGex vectors and expressed in *E.coli*, as described above. The products of protein expression and purification were analyzed by SDS-PAGE. Figure
 60 1A shows the results of affinity purification of the His-fusion protein, and Figure 1B shows the

results of expression of the GST-fusion in *E. coli*. Purified His-fusion protein was used to immunise mice, whose sera were used for FACS analysis (Figure 1C), a bactericidal assay (Figure 1D), and ELISA (positive result). These experiments confirm that ORF40-1 is a surface-exposed protein, and that it is a useful immunogen.

5 Figure 1E shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF40-1.

Example 2

The following partial DNA sequence was identified in *N. meningitidis* <SEQ ID 7>

```

1  ATGTTACGTT TGACTGCTTT AGCCGTATGC ACCGCCCTCG CTTTGGGCGC
51  GTGTTGCGCG CAAAATTCCG ACTCTGCCCC ACAAGCCAAA GaACAGGCGG
101 TTTCCGCGCG ACAAACCGAA GgCGCGTCCG TTACCGTCAA AACCGCGCGC
151 GCGGACGTTT AAATACCGCA AAACCCCGAA CGCATCGCGG TTTACGATTT
201 GGGTATGCTC GACACCTTGA GCAAACCTGGG CGTGAAAACC GGTGTTGTCG
251 TCGATAAAAA CCGCCTGCGG TATTTAGAGG AATATTTCAA AACGACAAAA
301 CCTGCCGGCA CTTTGTTCGA GCCGGATTAC GAAACGCTCA ACGCTTACAA
15 351 ACCGCAGCTC ATCATCATCG GCAGCCGCGC CgCCAAGGCG TTTGACAAAT
401 TGAACGAAAT CGCGCCGACC ATCGTmWTGA CCGCCGATAC CGCCAACCTC
451 AAAGAAAGTG CCAAGAGGCG ATCGACGCTG GCGCAAATCT TC..

```

This corresponds to the amino acid sequence <SEQ ID 8; ORF38>:

```

1  MLRLTALAVC TALALGACSP QNSDSAPQAK EQAVSAAQTE GASVTVKTAR
20 51  GDVQIPQNPE RIAVYDLGML DTLKSLGVKT GLSVDKNRLP YLEEYFKTTK
101 PAGTLFEPDY ETLNAYKPQL IIIGSRAAKA FDKLNEIAPT IXXTADTANL
151 KESAKEASTL AQIF..

```

Further work revealed the complete nucleotide sequence <SEQ ID 9>:

```

1  ATGTTACGTT TGACTGCTTT AGCCGTATGC ACCGCCCTCG CTTTGGGCGC
25 51  GTGTTGCGCG CAAAATTCCG ACTCTGCCCC ACAAGCCAAA GAACAGGCGG
101 TTTCCGCGCG ACAAACCGAA GGCGCGTCCG TTACCGTCAA AACCGCGCGC
151 GCGGACGTTT AAATACCGCA AAACCCCGAA CGCATCGCGG TTTACGATTT
201 GGGTATGCTC GACACCTTGA GCAAACCTGGG CGTGAAAACC GGTGTTGTCG
30 251 TCGATAAAAA CCGCCTGCGG TATTTAGAGG AATATTTCAA AACGACAAAA
301 CCTGCCGGCA CTTTGTTCGA GCCGGATTAC GAAACGCTCA ACGCTTACAA
351 ACCGCAGCTC ATCATCATCG GCAGCCGCGC CGCCAAGGCG TTTGACAAAT
401 TGAACGAAAT CGCGCCGACC ATCGAAATGA CCGCCGATAC CGCCAACCTC
451 AAAGAAAGTG CCAAGAGCG CATCGACGCG CTGGCGCAAA TCTTCGGCAA
501 ACAGGCGGAA GCCGACAAGC TGAAGGCGGA AATCGACGCG TCTTTTGAAG
35 551 CCGCGAAAAC TGCCGCACAA GGTAAGGCA AAGGTTTGGT GATTTTGGTC
601 AACGGCGGCA AGATGTCGGC TTTCGGCCCG TCTTCACGCT TGGGCGGCTG
651 GCTGCACAAA GACATCGGCG TTCCCGCTGT CGATGAATCA ATTAAGAAG
701 GCAGCCACGG TCAGCTATC AGCTTTGAAT ACCTGAAAGA GAAAAATCCC
751 GACTGGCTGT TTGTCTTGA CCGAAGCGCG GCCATCGGCG AAGAGGGTCA
40 801 GCGGCGGAAA GACGTGTTGG ATAATCCGCT GGTGCGGAA ACAACCGCTT
851 GGAAAAAAGG ACAGGTCGTG TACCTCGTTC CTGAAACTTA TTTGGCAGCC
901 GGTGGCGCGC AAGAGCTGCT GAATGCAAGC AAACAGGTTG CCGACGCTTT
951 TAACGCGGCA AAATAA

```

This corresponds to the amino acid sequence <SEQ ID 10; ORF38-1>:

```

45 1  MLRLTALAVC TALALGACSP QNSDSAPQAK EQAVSAAQTE GASVTVKTAR
51  GDVQIPQNPE RIAVYDLGML DTLKSLGVKT GLSVDKNRLP YLEEYFKTTK
101 PAGTLFEPDY ETLNAYKPQL IIIGSRAAKA FDKLNEIAPT IEMTADTANL
151 KESAKERIDA LAQIFGKQAE ADKLKAEIDA SFEEAKTAAQ GKKGKLVILV
201 NGGKMSAFGP SSRLGGWLHK DIGVPAVDES IKEGSHGQPI SFEYLKEKNP
50 251 DWLFVLDRSA AIGEEGQAAK DVLNPLVAE TTAWKKGQVV YLVPETYLAA

```

301 GGAQELLNAS KQVADAFNAA K*

Computer analysis of this amino acid sequence reveals a putative prokaryotic membrane lipoprotein lipid attachment site (underlined).

Further work identified the corresponding gene in strain A of *N.meningitidis* <SEQ ID 11>:

```

5      1 ATGTTACGTT TGA CTGCTTT AGCCGTATGC ACCGCCCTCG CTTTGGGCGC
      51 GTGTTGCGCG CAAAATTCCG ACTCTGCCCC ACAAGCCAAA GAACAGGCGG
    101 TTTCGCGCGC ACAATCCGAA GCGGTGTCCG TTACCGTCAA AACGGCGCGC
    151 GCGGATGTTC AAATACCGCA AAACCCCGAA CGTATCGCCG TTTACGATT
    201 GGGTATGCTC GACACCTTGA GCAAACCTGG CGTGAAACC GGTGTGTCG
    10 251 TCGATAAAAA CCGCTGCGG TATTTAGAGG AATATTTCAA AACGACAAA
      301 CCTGCCGGA CTTTGTTCGA GCCGATTAC GAAACGCTCA ACGTTACAA
      351 ACCGAGCTC ATCATCATCG GCAGCCGCGC AGCCAAAGCG TTTGACAAAT
      401 TGAACGAAAT CGCGCCGACC ATCGAAATGA CGCCGATAC CGCAACCTC
      451 AAAGAAAGTG CCAAGAGCG TATCGACGCG CTGGCGCAA TCTTCGGCAA
    15 501 AAAGCGGAA GCCGACAAGC TGAAGCGGGA AATCGACGCG TCTTTGAAG
      551 CCGCGAAAC TGCCGCGCAA GGCAAAGGCA AGGGTTTGGT GATTTTGGTC
      601 AACGGCGGCA AGATGTCCGC CTTCCGCCG TCTTCACGAC TGGCGGCTG
      651 GCTGCACAAA GACATCGCGC TTCCGCTGT TGACGAAGCC ATCAAAGAAG
      701 GCAGCCACGG TCAGCCTATC AGCTTTGAAT ACCTGAAAGA GAAAAATCCC
    20 751 GACTGGCTGT TTGTCTTGA CCGCAGCGCG GCCATCGCGC AAGAGGGTCA
      801 GCGCGCGAAA GACGTGTTGA ACAATCCGCT GGTGCGGAA ACAACCGCTT
      851 GGAAAAAAGG ACAAGTCGTT TACCTTGTT CTGAAACTTA TTTGGCAGCC
      901 GGTGGCGCGC AAGAGCTACT GAATGCAAGC AACAGGTTG CCGACGCTTT
      951 TAACGCGCA AAATAA
  
```

25 This encodes a protein having amino acid sequence <SEQ ID 12; ORF38a>:

```

      1 MLRLTALAVC TALALGACSP QNSDSAPQAK EQAVSAAQSE GVSVTVKTR
      51 GDVQIPQNP RIAYVDLGM DTL SKLGVKT GLSVDKNR LP YLEEFKTK
    101 PAGTLFEPDY ETLNAYKPQ L IIIGSRAAKA FDKLNEIAPT IEMTADTANL
    151 KESAKERIDA LAQIFGKKA E ADKLKAEIDA SF EAKTAAQ GKGLVILV
    201 NGGKMSAFGP SSR LGGWLHK DIGVPAVDEA I KEGSHGQPI SF EYLKEKNP
    251 DWLFVLD R SA AIGEEGQA AK DVLNNPLVAE TTAWKKGQV V YLVPETYLAA
    301 GGAQELLNAS KQVADAFNAA K*
  
```

The originally-identified partial strain B sequence (ORF38) shows 95.2% identity over a 165aa overlap with ORF38a:

```

35      10      20      30      40      50      60
    orf38.pep MLRLTALAVCTALALGACSPQNSDSAPQAKEQAVSAAQTEGASVTVKRTARGDVQIPQNP
    orf38a     MLRLTALAVCTALALGACSPQNSDSAPQAKEQAVSAAQSEGVSVTVKRTARGDVQIPQNP
      10      20      30      40      50      60
    40      70      80      90     100     110     120
    orf38.pep RIAYVDLGM DTL SKLGVKT GLSVDKNR LP YLEEFKTK PKAGTLFEPDYETLNAYKPQ
    orf38a     RIAYVDLGM DTL SKLGVKT GLSVDKNR LP YLEEFKTK PKAGTLFEPDYETLNAYKPQ
      70      80      90     100     110     120
    45      130     140     150     160
    orf38.pep IIIGSRAAKAFDKLNEIAPTIXXTADTANLKEAKE-ASTLAQIF
    orf38a     IIIGSRAAKAFDKLNEIAPT IEMTADTANLKEAKERIDALAQIFGKKA EADKLKAEIDA
      130     140     150     160     170     180
    50      190     200     210     220     230     240
    orf38a     SF EAKTAAQ GKGLVILVNGGKMSAFGPSSRLGGWLHKDIGVPAVDEAIKEGSHGQPI
  
```

55 The complete strain B sequence (ORF38-1) and ORF38a show 98.4% identity in 321 aa overlap:

```

    orf38a.pep    MLRLTALAVCTALALGACSPQNSDSAPQAKEQAVSAAQSEGVSVTVKTARGDVQIPQNPE
    orf38-1       MLRLTALAVCTALALGACSPQNSDSAPQAKEQAVSAAQTEGASVTVKTARGDVQIPQNPE
5   orf38a.pep    RIAVYDLGMLDTLSKLGVTGLSVVDKNRPLYEEYFKTTKPAGTLFEPDYETLNAYKPQL
    orf38-1       RIAVYDLGMLDTLSKLGVTGLSVVDKNRPLYEEYFKTTKPAGTLFEPDYETLNAYKPQL
10  orf38a.pep    IIIGSRAAKAFDKLNEIAPTIEMTADTANLKESAKERIDALAQIFGKKAEDKLKAEIDA
    orf38-1       IIIGSRAAKAFDKLNEIAPTIEMTADTANLKESAKERIDALAQIFGKKAEDKLKAEIDA
15  orf38a.pep    SFEAAKTAAQGKGKGLVILVNGGKMSAFGPSSRLGGWLHKDIGVPAVDEAIKEGSHGQPI
    orf38-1       SFEAAKTAAQGKGKGLVILVNGGKMSAFGPSSRLGGWLHKDIGVPAVDESKEGSHGQPI
20  orf38a.pep    SFEYLKEKNPDWLFVLDRSAAIGEEGQAAKDVLDNPLVAETTAWKKGQVVYLVPEYTLAA
    orf38-1       SFEYLKEKNPDWLFVLDRSAAIGEEGQAAKDVLDNPLVAETTAWKKGQVVYLVPEYTLAA
    orf38a.pep    GGAQELLNASKQVADAFNAAK
    orf38-1       GGAQELLNASKQVADAFNAAK

```

Computer analysis of these sequences revealed the following:

25 Homology with a lipoprotein (lipo) of *C.jejuni* (accession number X82427)

ORF38 and lipo show 38% aa identity in 96 aa overlap:

```

    Orf38: 40  EGASVTVKTARGDVQIPQNPERIAVYDLGMLDTLSKLGVTGLS-VDKNRPLYEEYFKT 98
                EG S  VK + G + P+NP ++ + DLG+LDT  L +  ++ V  LP  + FK
30  Lipo:  51  EGDSFLVKDSLGENKTPKNPSKVILDLGILDTFDALKLNDKVAGVPAKNLPKYLQQFKN 110
    Orf38: 99  TKPAGTLFEPDYETLNAYKPQLIIIGSRAAKAFDKL 134
                G + + D+E +NA KP LIII  R +K +DKL
    Lipo: 111  KPSVGGVQQVDFAINALKPDLIISGRQSKFYDKL 146

```

Based on this analysis, it was predicted that this protein from *N.meningitidis*, and its epitopes, could
 35 be useful antigens for vaccines or diagnostics.

ORF38-1 (32kDa) was cloned in pET and pGex vectors and expressed in *E.coli*, as described above. The products of protein expression and purification were analyzed by SDS-PAGE. Figure 2A shows the results of affinity purification of the His-fusion protein, and Figure 2B shows the results of expression of the GST-fusion in *E.coli*. Purified His-fusion protein was used to immunise
 40 mice, whose sera were used for Western blot analysis (Figure 2C) and FACS analysis (Figure 2D). These experiments confirm that ORF38-1 is a surface-exposed protein, and that it is a useful immunogen.

Figure 2E shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF38-1.

Example 3

45 The following *N.meningitidis* DNA sequence was identified <SEQ ID 13>:

1 ATGAACTTC TGACCACCGC AATCCTGTCT TCCGCAATCG CGCTCAGCAG
 51 TATGGCTGCC GCCGCTGGCA CGGACAACCC CACTGTTGCA AAAAAAACCG
 101 TCAGCTACGT CTGCCAGCAA GGTAAAAAG TCAAAGTAAC CTACGGCTTC
 151 AACAAACAGG GTCTGACCAC ATACGCTTCC GCCGTCATCA ACGGCAAACG
 5 201 CGTGCAAATG CCTGTCAATT TGGACAAATC CGACAATGTG GAAACATTCT
 251 ACGGCAAAGA AGGCGGTTAT GTTTGGGTA CCGGCGTGAT GGATGGCAAA
 301 TCCTACCGCA AACAGCCCAT TATGATTACC GCACCTGACA ACCAAATCGT
 351 CTTCAAAGAC TGTTCCCCAC GTTAA

This corresponds to the amino acid sequence <SEQ ID 14; ORF44>:

10 1 MKLLTTAILS SAIALSSMAA AAGTDNPTVA KKTVSIVCQO GKKVKVITYGF
 51 NKQGLTTYAS AVINGKRVQM PVNLDKSDNV ETFYKKEGGY VLGTGVMDGK
 101 SYRKQPIMIT APDNQIVFKD CSPR*

Computer analysis of this amino acid sequence predicted the leader peptide shown underlined.

Further work identified the corresponding gene in strain A of *N.meningitidis* <SEQ ID 15>:

15 1 ATGAACTTC TGACCACCGC AATCCTGTCT TCCGCAATCG CGCTCAGCAG
 51 TATGGCTGCT GCTGCCGGCA CGAACAACCC CACCGTTGCC AAAAAAACCG
 101 TCAGCTACGT CTGCCAGCAA GGTAAAAAG TCAAAGTAAC CTACGGCTTT
 151 AACAAACAGG GCCTGACCAC ATACGCTTCC GCCGTCATCA ACGGCAAACG
 20 201 TGTGCAAATG CCTGTCAATT TGGACAAATC CGACAATGTG GAAACATTCT
 251 ACGGCAAAGA AGGCGGTTAT GTTTGGGTA CCGGCGTGAT GGATGGCAAA
 301 TCCTATCGCA AACAGCCTAT TATGATTACC GCACCTGACA ACCAAATCGT
 351 CTTCAAAGAC TGTTCCCCAC GTTAA

This encodes a protein having amino acid sequence <SEQ ID 16; ORF44a>:

25 1 MKLLTTAILS SAIALSSMAA AAGTNNPTVA KKTVSIVCQO GKKVKVITYGF
 51 NKQGLTTYAS AVINGKRVQM PVNLDKSDNV ETFYKKEGGY VLGTGVMDGK
 101 SYRKQPIMIT APDNQIVFKD CSPR*

The strain B sequence (ORF44) shows 99.2% identity over a 124aa overlap with ORF44a:

		10	20	30	40	50	60
30	orf44.pep	<u>MKLLTTAILSSAIALSSMAAAAGTDNPTVAKKT</u> VSIVCQOGKKVKVITYGFNKQGLTTYAS					
	orf44a	<u>MKLLTTAILSSAIALSSMAAAAGTNNPTVAKKT</u> VSIVCQOGKKVKVITYGFNKQGLTTYAS					
		10	20	30	40	50	60
35	orf44.pep	AVINGKRVQMPVNLDKSDNVETFYKKEGGYVLGTGVMDGKSYRKQPIMITAPDNQIVFKD					
	orf44a	AVINGKRVQMPVNLDKSDNVETFYKKEGGYVLGTGVMDGKSYRKQPIMITAPDNQIVFKD					
		70	80	90	100	110	120
40	orf44.pep	CSPRX					
	orf44a	CSPRX					

Computer analysis gave the following results:

Homology with the LecA adhesin of *Eikenella corrodens* (accession number D78153)

45 ORF44 and LecA protein show 45% aa identity in 91 aa overlap:

Orf44 33 TVSYVCQOGKKVKVITYGFNKQGLTTYASAVINGKRVQMPVNLDKSDNVETFYKKEGGYVL 92
 +V+YVCQOG+++ V Y FN G+ T A +N + +++P NL SDNV+T + GY L
 LecA 135 SVAYVCQOGRRLNVNRYFNSAGVPTS AELRVNRRNLRLPYNLSASDNVDTVF-SANGYRL 193
 50 Orf44 93 GTGVMDGKSYRKQPIMITAPDNQIVFKDCSP 123
 T MD +YR Q I+++AP+ Q+++KDCSP

LecA 194 TTNAMDSANYRSQDIIVSAPNGQMLYKDCSP 224

Based on homology with the adhesin, it was predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

ORF44-1 (11.2kDa) was cloned in pET and pGex vectors and expressed in *E.coli*, as described above. The products of protein expression and purification were analyzed by SDS-PAGE. Figure 3A shows the results of affinity purification of the His-fusion protein, and Figure 3B shows the results of expression of the GST-fusion in *E.coli*. Purified His-fusion protein was used to immunise mice, whose sera were used for ELISA, which gave positive results, and for a bactericidal assay (Figure 3C). These experiments confirm that ORF44-1 is a surface-exposed protein, and that it is a useful immunogen.

Figure 3D shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF44-1.

Example 4

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 17>

```

15      1  ..GGCACC GAAT TCAAAACCAC CCTTTCGGGA GCCGACATAC AGGCAGGGGT
      51  GGGTGAAAAA GCCCGAGCCG ATGCGAAAAAT TATCCTAAAA GGCATCGTTA
      101  ACCGCATCCA AACC GAAGAA AAGCTGGAAT CCAACTCGAC CGTATGGCAA
      151  AAGCAGGCCG GAAGCGGCAG CACGGTTGAA ACGCTGAAGC TACCGAGCTT
      201  TGAAGGGCCG GCACTGCCTA AGCTGACCGC TCCCGGCCGC TATATCGCCG
      251  ACATCCCCAA AGGCAACCTC AAAACCGAAA TCGAAAAGCT GGCCAAACAG
      20  301  CCCGAATATG CCTATCTGAA ACAGCTTCAG ACGGTCAAGG ACGTGAAC TG
      351  GAACCAAGTA CAGCTCGCTT ACGACAAATG GGAATAATAA CAGGAAGGCC
      401  TAACCGGAGC CGGAGCCGCA ATTANCGCAC TGGCCGTAC CGTGGTCACC
      451  TCAGGCGCAG GAACCGGAGC CGTATTGGGA TTAANACGNG TGGCCGCCGC
      501  CGCAACCGAT GCAGCATTT...

```

25 This corresponds to the amino acid sequence <SEQ ID 18; ORF49>:

```

      1  ..GTEFKTTL SG ADIQAGVGEK ARADAKIILK GIVNRIQTEE KLESNSTVWQ
      51  KQAGSGSTVE TLKLPSEFGP ALPKLTAPGG YIADIPKGNL KTEIEKLAKQ
      101  PEYAYLKQLQ TVKDVNWNQV QLAYDKWDYK QEGLTGAGAA IXALAVTVVT
      151  SGAGTGAVLG LXRVAATAATD AAF..

```

30 Further work revealed the complete nucleotide sequence <SEQ ID 19>:

```

      1  ATGCAACTGC TGGCAGCCGA AGGCATTCAC CAACACCAAT TGAATGTTCA
      51  GAAAAGTACC CGTTTCATCG GCATCAAAGT GGGTAAAAGC AATTACAGCA
      101  AAAACGAGCT GAACGAAACC AACTGCCCCG TACGCGTTAT CGCCCAACAA
      151  GCCAAACCC GTTCCGGCTG GGATACCGTA CTCGAAGGCA CCGAATTCAA
      35  201  AACCACCCTT TCCGAGCCG ACATACAGGC AGGGGTGGGT GAAAAAGCCC
      251  GAGCCGATGC GAAAATTATC CTAAAAGGCA TCGTTAACCG CATCCAAACC
      301  GAAGAAAAGC TGGAATCCAA CTCGACCGTA TGGCAAAAGC AGGCCGGAAG
      351  CGGCAGCAGC GTTGAAACGC TGAAGCTACC GAGCTTTGAA GGGCCGGCAC
      401  TGCCTAAGCT GACCGCTCCC GCGGCTATA TCGCCGACAT CCCCAAAGGC
      40  451  AACCTCAAAA CCGAATCGA AAAGCTGGCC AAACAGCCCG AATATGCCTA
      501  TCTGAAACAG CTTCAGACGG TCAAGGACGT GAACTGGAAC CAAGTACAGC
      551  TCGCTTACGA CAAATGGGAC TATAAACAGG AAGGCCTAAC CGGAGCCGGA
      601  GCCGCAATTA TCGCACTGGC CGTTACCGTG GTCACCTCAG GCGCAGGAAC
      651  CGGAGCCGTA TTGGGATTAA ACGGTGCGGC CGCCGCCGCA ACCGATGCAG

```

	1	QMLLAAEGIH	QHQLNVQKST	RFIGIKVGKS	NYSKNEINET	KLPVRVIAQT
	51	AKTRSGWDTV	LEGTEFKTTL	SGADIQAGVG	EKARADAKII	LKGIVNRIQT
30	101	EEKLESNSTV	WQKQAGSGST	VETLKLPSFE	QPALPKLTAP	GGYIADIPKG
	151	NLKTIEIKLA	KOPEYAYLKQ	LQTVKDVNNW	QVQLADKWD	YKQEGLTGAG
	201	AAIIALAVTV	QTSAGTGAV	LGLNAAAAA	TDAAFASLAS	QASVSFTNNK
	251	GNIGNTLKEL	GRSSTVKNLM	VAVATAGVAD	KIGASALNNV	SDKQWINNLT
	301	VNLANAGSAA	LINTAVNGGS	LKDNLEANIL	AALVNTAHGE	AASKIKQLDQ
	351	HYIAHKIAHA	IAGCAAAAAA	KGKQDGAIG	AAVGEILGET	LLDGRDPGSL
35	401	NVKDRAKIIA	KAKLAAGAVA	ALSKGDVSTA	ANAAAVAVEN	NSLNDIQDRL
	451	LSGNYALCMS	AGGAESFCES	YRPLGLPHFV	SVSGEMKLPN	KFGNRMVNGK
	501	LIINTRNGNV	YFSVGKIWST	VKSTKSNISG	VSVGWVLNVS	PNDYLKEASM
	551	NDFRNSNQNK	AYAEMISQTL	VGESVGGSLC	LTRACFVSST	TISKSXSPFK
	601	DSKIIGEIGL	GSGVAAGVEK	TIYIGNIKDI	DKFISANIKK	*

ORF49 shows 86.1% identity over a 173aa overlap with an ORF (ORF49a) from strain A of *N. meningitidis*:

```

45      orf49.pep      10      20      30
                        GTEFKTTLSGADIQAGVGEKARADAKIILK
                        |||||:|||||:|||||:|||||:
orf49a      SKNELNETKLPVRVVAQXAATRSGWDTVLEGTEFKTTLAGADIQAGVXEKARVDAKIILK
                        40      50      60      70      80      90

50      orf49.pep      40      50      60      70      80      90
                        GIVNRIQTEEKLESNSTVWQKQAGSGSTVETLKLPSFEGPALPKLTAPGGYIADIPKGNL
                        |||||:|||||:|||||:|||||:|||||:|||||:|||||:|||||:|||||:
orf49a      GIVNRIQSEEKLETNSTVWQKQAGRSTIETLKLPSFESPTPFKLSAPGGYIVDIPKGNL
                        100     110     120     130     140     150

55      orf49.pep      100     110     120     130     140     150
                        KTEIEKLAKQPEYAYLKQLQTVKDVNNQVQLAYDKWDYKQEGLTGAGAAIXALAVTVVT
                        |||||:|||||:|||||:|||||:|||||:|||||:|||||:|||||:|||||:

```

```

      orf49a      KTEIEKLSKQPEYAYLKQLQVAKNINWNQVQLAYDRWDYKQEGLTEAGAAIIIALAVTVVT
                  160      170      180      190      200      210
5      orf49.pep      SGAGTGAVLGLXRVAAAATDAAF
                      ||||| : |||||
      orf49a      SGAGTGAVLGLNGAXAAATDAAFASLASQASVSFINNKGDVGKTLKELGRSSTVKNLVVA
                      220      230      240      250      260      270

```

ORF49-1 and ORF49a show 83.2% identity in 457 aa overlap:

10	orf49a.pep	XQLLAEEGIHKHELDVQKSRRFIGIKVGXSNYSKNELNETKLPVRVVAQXAATRSQWDTV : : : : : :
	orf49-1	MQLLAAEGIHQHLNVQKSTRFIFIGIKVGXSNYSKNELNETKLPVRVIAQTAKTRSGWDTV
15	orf49a.pep	LEGTEFKTTLAGADIQAGVXEKARVDAKIILKGIVNRIQSEEKLETNSTVWQKQAGRGS : : : : : : : : : : : :
	orf49-1	LEGTEFKTTLSGADIQAGVGEKARADAKIILKGIVNRIQTEEKLESNSTVWQKQAGSGS
20	orf49a.pep	IETLKLPSFESPTPPKLSAPGGYIVDIPKGNLKTEIEKLSKQPEYAYLKQLQVAKNINWN : : : : : : : : : : : : : : : :
	orf49-1	VETLKLPSFEGPALPKLTAPGGYIADIPKGNLKTEIEKLAKQPEYAYLKQLQTVKDVNWN
	orf49a.pep	QVQLAYDRWDYKQEGLTEAGAAI IALAVTVVTSGAGTGAVLGLNGAXAAATDAAFASLAS : : : : : : : : : : : : : : :
	orf49-1	QVQLAYDKWDYKQEGLTGAGAAI IALAVTVVTSGAGTGAVLGLNGAAAAATDAAFASLAS
25	orf49a.pep	QASVSFINNKGVDGKTLKELGRSSTVKNLVVAATAGVADKIGASALXNVSDKQWINNLT : : : : : : : : : : : : : : :
	orf49-1	QASVSFINNKGNI GNTLKELGRSSTVKNLVAVATAGVADKIGASALNNVSDKQWINNLT
30	orf49a.pep	VNLANAGSAALINTAVNGGSLKDXLEANILAALVNTAHGEAASKIKQLDQHYIVHKIAHA : : : : : : : : : : : : : : :
	orf49-1	VNLANAGSAALINTAVNGGSLKDNLEANILAALVNTAHGEAASKIKQLDQHYIAHKIAHA
35	orf49a.pep	IAGCAAAAANKGKCQDGAIGAAGVEIVGEALTNGKNPDTLTAKEREQILAYSKLVAGTVS : : : : : : : : : : : : : : :
	orf49-1	IAGCAAAAANKGKCQDGAIGAAGVEILGETLLDGRDPGSLNVKDRAKIIAKAKLAAGAVA
	orf49a.pep	GVVGGDVNAAAANAEEVAVKNNQLSDXEGREFDNEMTACAKQNPQLCRKNTVKKYQNVD : : : : : : : : : : : : : : : :
40	orf49-1	ALSKGDVSTAANAAAVAVENNSLNDIQDRLLSGNYALCMSAGGAESFCESYRPLGLPHFV
	orf49a.pep	KRLAASIAICTDISRSTECRTIRKQHLIDSRSLHSSWEAGLIGKDDWEYKLFKSKSYTQAD
	orf49-1	SVSGEMKLPNKFNGRMVNGKLIINTRNGNVYFVSGKIIWSTVKSTKSNISGVSVGWVLNV

45 The complete length ORF49a nucleotide sequence <SEQ ID 21> is:

	1	NTGCAACTGC	TGGCAGAAGA	AGGCATCCAC	AAGCACGAGT	TGGATGTCCA
	51	AAAAAGCCGC	CGCTTTATCG	GCATCAAGGT	AGGTNAGAGC	AATTACAGTA
	101	AAAACGAAT	GAAACGAAAC	AAATTGCGCT	TCCGCGTCGT	CGCCCCAAAT
50	151	CGAGCCACCC	GTTCAGCGTG	GGATACCGTG	CTCGAAGGTA	CCGAATTCAA
	201	AACCAGCGTG	GCCGGTGC GG	ACATTCAAGC	AGGTGTANGC	GAAAAAGCCC
	251	GTGTCGATGC	GAAAAATTATC	CTCAAAGGCA	TTGTGAACCG	TATCCAGTCG
	301	GAAAGAAAAAT	TAGAAACCAA	CTCAACCGTA	TGGCAGAAAC	AGGCCGAGC
	351	CGGCAGCACT	ATCGAAACGC	TAAAACTGCC	CAGCTTCGAA	AGCCCTACTC
55	401	CGCCCCAAAT	GTCCGCAACC	GGCGGNTATA	TCGTGCACAT	TCCGAAAGGC
	451	AATCTGAAAA	CCGAAATCGA	AAAGCTGTCC	AAACAGCCCG	AGTATGCCTA
	501	TCTGAAACAG	CTCCAAGTAG	CGAAAAACAT	CAACTGGAAT	CAGGTGCAGC
	551	TTGCTTACGA	CAGATGGGAC	TACAAACAGG	AGGGCTTAAAC	CGAAGCAGGT
	601	GCGGCGATTA	TCGCACTGGC	CGTTACCGTG	GTCACTTCAG	GCGCAGGAAC
60	651	CGGAGCCGTA	TGGGATTAA	ACGGTGCGNC	CGCCGCCGCA	ACCGATGCAG
	701	CATTGCGCTC	TTTGCCAGC	CAGGCTTCCG	TATCGTTTAT	CAACAACAAA
	751	GGCGATGTCT	GCAAACCCCT	GAAAGAGCTG	GGCAGAAGCA	GCACGGTGAA
	801	AAATCTGGTG	GTTCCGCGCG	CTACCGCAGG	CGTAGCCGAC	AAAACTCGGC
	851	CTTCGGCACT	GANCAATGTC	AGCGATAAGC	AGTGGATCAA	CAACCTGACC
	901	GTCAACCTAG	CCAATGCGGG	CAGTGCCGCA	CTGATTATAA	CCGCTGTCAA
65	951	CGGCCGCCAGC	CTGAAAGACA	NTCTGGAAGC	GAAATATCCTT	GCGGCTTTTG
	1001	TCAATACCCG	GCATGGAGAA	GCAGCCAGTA	AAATACAACA	GTTGGATTAG

1051 CACTACATAG TCCACAAGAT TGCCCATGCC ATAGCGGGCT GTGCGGCAGC
 1101 GCGGCGGAAT AAGGGCAAGT GTCAGGATGG TGCGATAGGT GCGGCTGTGG
 1151 GCGAGATAGT CGGGGAGGCT TTGACAAACG GCAAAAATCC TGACACTTTG
 1201 ACAGCTAAAG AACGCGAACA GATTTTGCCA TACAGCAAAC TGGTTGCCGG
 1251 TACGGTAAGC GGTGTGGTCG GCGGCGATGT AAATGCGGCG GCGAATGCGG
 1301 CTGAGGTAGC GGTGAAAAAT AATCAGCTTA GCGACNAAGA GGGTAGAGAA
 1351 TTTGATAACG AAATGACTGC ATGCGCCAAA CAGAATANTC CTCAACTGTG
 1401 CAGAAAAAAT ACTGTAAAAA AGTATCAAAA TGTGCTGAT AAAAGACTTG
 1451 CTGCTTCGAT TGCAATATGT ACGGATATAT CCCGTAGTAC TGAATGTAGA
 1501 ACAATCAGAA AACAAACATT GATCGATAGT AGAAGCCTTC ATTCATCTTG
 1551 GGAAGCAGGT CTAATTGGTA AAGATGATGA ATGGTATAAA TTATTCAGCA
 1601 AATCTTACAC CCAAGCAGAT TTGGCTTTAC AGTCTTATCA TTTGAATACT
 1651 GCTGCTAAAT CTTGGCTTCA ATCGGGCAAT ACAAAGCCTT TATCCGAATG
 1701 GATGTCCGAC CAAGGTTATA CACTTATTTC AGGAGTTAAT CCTAGATTCA
 1751 TTCCAATACC AAGAGGGTTT GTAAAACAAA ATACACCTAT TACTAATGTC
 1801 AAATACCCGG AAGGCATCAG TTTGATACA AACCTANAAA GACATCTGGC
 1851 AAATGCTGAT GGTTTTAGTC AAGAACAGGG CATTAAAGGA GCCCATAACC
 1901 GCACCAATNT TATGCGAGAA CTAATTCAC GAGGAGGANG NGTAAAACTC
 1951 GAAACCCANA CTGATATTGA AGGCATTACC CGAATTAAAT ATGAGATTCC
 2001 TACACTAGAC AGGACAGGTA AACCTGATGG TGGATTTAAG GAAATTTCAA
 2051 GTATAAAAAC TGTTTATAAT CCTAAAAANT TTTNNGATGA TAAAATACTT
 2101 CAAATGGCTC ANATGCTGN TTCACAAGGA TATTCAAAG CCTCTAAAT
 2151 TGCTCAAAAT GAAAGAACTA AATCAATATC GGAAGAAAA AATGTCATTTC
 2201 AATTCTCAGA AACCTTTGAC GGAATCAAAT TTAGANNNTA TNTNGATGTA
 2251 AATACAGGAA GAATTACAAA CATTACCCCA GAATAATTTA A

This encodes a protein having amino acid sequence <SEQ ID 22>:

1 XQLLAEEGIH KHELDVQKSR RFIGIKVGXS NYSKNELNET KLPVRVVAQX
 51 AATRSGWDTV LEGTEFKTTL AGADIQAGVX EKARVDAKII LKGIVNRIQS
 101 EEKLETNSTV WQKQAGRGST IETLKLPSFE SPTPPKLSAP GGYIVDIPKG
 151 NLKTEIEKLS KOPEYAYLKQ LQVAKNINWN QVQLAYDRWD YKQEGLETEAG
 201 AAIIALAVTV VTSGAGTGAV LGLNGAXAAA TDAAFASLAS QASVSFINNK
 251 GDVGKTLKEL GRSSTVKNLV VAAATAGVAD KIGASALXNV SDKQWINNLT
 301 VNLNAGSAA LINTAVNGGS LKDXLEANIL AALVNTAHGE AASKIKQLDQ
 351 HYIVHKIAHA IAGCAAAAAN KGKQDGAIG AAVGEIVGEA LTNGKNPDTL
 401 TAKEREQILA YSKLVAGTVS GVVGGDVNAA ANAAEVAVKN NQLSDXEGRE
 451 FDNEMTACAK QNXPOLCRKN TVKKYQNVAD KRLAASIAIC TDISRSTECR
 501 TIRKQHLIDS RSLHSSWEAG LIGKDEWYK LFSKSYTQAD LALQSYHLNT
 551 AAKSWLQSGN TKPLSEWMSD QGYTLISGVN PRFIPIPRGF VKQNTPIITNV
 601 KYPEGISFDT NLXRLHANAD GFSQEQGIK AHNRTNXMAE LNSRGGXVKS
 651 ETXTDIEGIT RIKYEIPTLD RTGKPDGGFK EISSIKTVYN PKFXDDKIL
 701 QMAQXAXSQG YSKASKIAQN ERTKSISERK NVIQFSETFD GIKFRXYXDV
 751 NTGRITNIHP E*

Based on the presence of a putative transmembrane domain, it is predicted that these proteins from *N.meningitidis*, and their epitopes, could be useful antigens for vaccines or diagnostics.

45 Example 5

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 23>

1 ..CGGATCGTTG TAGGTTTGGC GATTTCTTGC GCCGTAGTCA CCGTAGTCCC
 51 AAGTATAACC CAAGGCTTTG TCTTCGCCTT TCATTCCGAT AAGGGATATG
 101 ACGCTTTGGT CGGTATAGCC GTCTTGGGAA CTTTGTCCA CCCAACGCAT
 151 ATCTGCCTGC GGATTCTCAT TGCCGCTTCT TGGCTGCTGA TTTTCTGGCC
 201 TTCGCGTTTT TCAACTTCGC GCTTGAGGGC TTCGGCATAT TTGTCGGCCA
 251 ACGCCATTTC TTTCCGATGC AGCTGCCTAT TGTTCGAATC TACATTGCGA
 301 CCCACCACAG CACCACCACT ACCACCAGTT GCATAG

This corresponds to the amino acid sequence <SEQ ID 24; ORF50>:

55 1 ..RIVVGLRISC AVVTVVPSIT QGFVFAFHS D KGYDALVGIA VLGTFFVHPTH
 51 ICLRILIAAS WLLIFLPSRF STSRLRASAY LSANAISFGC SCLLFQSTFA
 101 PTTAPPLPPV A*

Computer analysis predicts two transmembrane domains and also indicates that ORF50 has no significant amino acid homology with known proteins.

Based on the presence of a putative transmembrane domain, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

5 Example 6

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 25>

```

      1 ..AAGTTTGACT TTACCTGGTT TATTCGCGC GTAATCAAAT ACCGCCGGTT
      51 GTTTTTTGAA GTATTGGTGG TGTCGGTGGT GTTGCAGCTG TTTGCGCTGA
    101 TTACGCCCTCT GTTTTTCCAA GTGGTGATGG ACAAGGTGCT GGTACATCGG
    151 GGATTCTCTA CTTTGGATGT GGTGTCGGTG GCTTTGTTGG TGGTGTGCGT
    201 GTTTGAGATT GTTTGGGGCG GTTTCGGGAC GTATCTGTTT GCACATACGA
    251 CTTACCGTAT TGATGTGGAA TTGGGCGCGC GTTTGTCCG GCATCTGCTT
    301 TCCCTGCCTT TATCCTATTT CGAGCACAGA CGAGTGGGTG ATACGGTGGC
    351 TCGGGTGCAG GAATTGGAGC AGATTGCGAA TTTCTTGACC GGTACGGCGC
    15 401 TGACTTCGGT GTTGGATTG GCGTTTTCGT TTATCTTCTT GCGCGTGATG
    451 TGGTATTACA GCTCCACTCT GACTTGGGTG GTATTGGCTT CGTTG.....
          //
    1451 .....
    1501 ..... ..ATTGCGC
    20 1551 CAACCGGACG GTGCTGATTA TCGCCACCG TCTGTCCACT GTTAAACCGG
    1601 CACACCGGAT CATTGCCATG GATAAAGCA GGATTGTGGA AGCGGGAACA
    1651 CAGCAGGAAT TGCTGGCGAA CG..AACGGA TATTACCGCT ATCTGTATGA
    1701 TTACAGAAC GGGTAG
  
```

This corresponds to the amino acid sequence <SEQ ID 26; ORF39>:

```

    25 1 ..KFDFTWFIPA VIKYRRLEFE VLVVSVLQL FALITPLEFQ VMDKVLVHR
      51 GFSTLDVSV ALLVVSLEFI VLGLRITYLF AHTTSRIDVE LGARLFRHLL
    101 SLPLSYFEHR RVGDTVARVR ELEQIRNFLT GQALTSVLDL AFSFIFLAVM
    151 WYYSSTLTWV VLASL.....
          //
    30 501 ..... ICAVRT VLIIAHRLST VKTAHRIAM DKGRIVEAGT
    551 QEELLANXNG YYRYLYDLQN G*
  
```

Further work revealed the complete nucleotide sequence <SEQ ID 27>:

```

      1 ATGTCTATCG TATCCGCACC GCTCCCCGCC CTTTCCGCC TCATCATCCT
      51 CGCCCATAC CACGGCATTG CCGCCAATCC TGCCGATATA CAGCATGAAT
    35 101 TTTGTACTTC CGCACAGAGC GATTTAAATG AAACGCAATG GCTGTTAGCC
    151 GCCAAATCTT TGGGATTGAA GGCAAAGGTA GTCCGCCAGC CTATTAAACG
    201 TTTGGCTATG GCGACTTTAC CCGCATTGGT ATGGTGTGAT GACGGCAACC
    251 ATTTCAATTT GGCCAAAACA GACGGTGAGG GTGAGCATGC CCAATTTTTG
    301 ATACAGGATT TGGTTACGAA TAAGTCTGCG GTATTGTCTT TTGCCGAATT
    40 351 TTCTAACAGA TATTCGGGCA AACTGATATT GGTGCTTCC CGCGCTTCGG
    401 TATTGGGCG TTTGGCAAAG TTTGACTTTA CCTGGTTTAT TCCGGCGGTA
    451 ATCAAATACC GCCGGTTGTT TTTTGAAGTA TTGGTGGTGT CGGTGGTGT
    501 GCAGCTGTTT GCGCTGATTA CGCCTCTGTT TTTCCAAGTG GTGATGGACA
    551 AGGTGCTGGT ACATCGGGGA TTCTCTACTT TGGATGTGGT GTCGGTGGCT
    45 601 TTGTTGGTGG TGTCGCTGTT TGAGATTGTG TTGGGCGGTT TGCGGACGTA
    651 TCTGTTTGCA CATACGACTT CACGTATTGA TGTGGAATTG GGCAGCGGTT
    701 TGTTCCGGCA TCTGCTTTCC CTGCCCTTAT CCTATTTCGA GCACAGACGA
    751 GTGGGTGATA CGGTGGCTCG GGTGCGGGAA TTGGAGCAGA TTCGCAATTT
    801 CTTGACCGGT CAGGCGCTGA CTTGCGTGTG GGATTGGCG TTTTCGTTTA
    50 851 TCTTTCTGGC GGTGATGTGG TATTACAGCT CCACTCTGAC TTGGGTGGTA
    901 TTGGCTTCGT TGCCTGCCTA TCGTGTGTTG TCGGCATTTA TCAGTCCGAT
    951 ACTGCGGACG CGTCTGAACG ATAAGTTCG CCGCAATGCA GACAACCACT
    1001 CGTTTTTAGT AGAAAGCATC ACTGCGGTGG GTACGGTAAA GGCAGATGGC
    1051 GTGGAGCCGC AGATGACGCA GCGTTGGGAC AATCAGTTGG CGGCTTATGT
  
```

5
10
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20

```

1101 GGCTTCGGGA TTTCGGGTAA CGAAGTTGGC GGTGGTCGGC CAGCAGGGGG
1151 TGCAGCTGAT TCAGAAGCTG GTGACGGTGG CGACGTTGTG GATTGGCGCA
1201 CGGCTGGTAA TTGAGAGCAA GCTGACGGTG GGGCAGCTGA TTGCGTTTAA
1251 TATGCTCTCG GGACAGGTGG CGGCGCCTGT TATCCGTTTG GCGCAGTTGT
1301 GGCAGGATTT CCAGCAGGTG GGGATTTTCG TGGCGCGTTT GGGGGATATT
1351 CTGAATGCGC CGACCGAGAA TCGCTCTTCG CATTTGGCTT TGCCCGATAT
1401 CCGGGGGGAG ATTACGTTTC AACATGTCGA TTTCCGCTAT AAGGCGGACG
1451 GCAGGCTGAT TTTGCAGGAT TTGAACCTGC GGATTCGGGC GGGGGAAGTG
1501 CTGGGGATTG TGGGACGTTT GGGGTCGGGC AAATCCACAC TCACCAAATT
1551 GGTGCAGCGT CTGTATGTAC CGGAGCAGGG ACGGGTGTG GTGGACGGCA
1601 ACGATTTGGC TTTGGCCGCT CCTGCCTGGC TCGGGCGGCA GGTCCGCGTG
1651 GTCTTGCAGG AGAATGTGCT GCTCAACCGC AGCATACGCG ACAATATCGC
1701 GCTGACGGAT ACGGGTATGC CGCTGGAACG CATTATCGAA GCAGCCAAAC
1751 TGGCGGGCGC ACACGAGTTT ATTATGGAGC TGCCGGAAGG CTACGGCACC
1801 GTGGTGGGCG AACAGGGGCG CGGCTTGTGC GCGCGACAGC GGCAGCGTAT
1851 TGGGATTGCC CGCGCGTTAA TCACCAATCC GCGCATTCTG ATTTTGTATG
1901 AAGCCACCAG CGCGCTGGAT TATGAAAGTG AACGAGCGAT TATGCAGAAC
1951 ATGCAGGCCA TTTGCGCCAA CCGGACGGTG CTGATTATCG CCCACCGTCT
2001 GTCCACTGTT AAAACGGCAC ACCGGATCAT TGCCATGGAT AAAGCGAGA
2051 TTGTGGAAGC GGGAACACAG CAGGAATTGC TGGCGAAGCC GAACGGATAT
2101 TACCGCTATC TGTATGATT ACAGAACGGG TAG

```

This corresponds to the amino acid sequence <SEQ ID 28; ORF39-1>:

25
30
35

```

1 MSIVSAPLPA LSALIILAHY HGIAANPADI QHEFCTSAQS DLNETQWLLA
51 AKSLGLKAKV VRQPIKRLAM ATLPALVWCD DGNHFILAKT DGEGEHAQFL
101 IQDLVTNKSA VLSFAEFSNR YSGKLILVAS RASVLGSLAK FDFTFWIFAV
151 IKYRRLFFEV LVVSVVLQLE ALITPLFFQV VMDKVLVHRG FSTLDVVSVA
201 LLVVSLEIV LGGLRITYLFA HTTSRIDVEL GARLFRHLLS LPLSYFEHRR
251 VGDTVARVRE LEQIRNFLTQ QALTSVLDLA FSFIFLAVMW YYSSTLTWVV
301 LASLPAYAFW SAFISPILRT RLNDKFARNA DNQSEFVESI TAVGTVKAMA
351 VEPQMTQRWD NQLAAYVASG FRVTKLAVVG QQGVQLIQKL VTVATLWIGA
401 RLVIESKLTV GQLIAFNMLS GQVAAPVIRL AOLWQDFQOV GISVARLGI
451 LNAPTENASS HLALPDIRGE ITFEHVDFRY KADGRLLIQD LNLIRIRAGEV
501 LGIVGRSGSG KSTLTKLVQR LYVPEQGRVL VDGNDLALAA PAWLRRQGV
551 VLQENVLLNR SIRDNIATD TGMPLERIE AAKLAGAHEF IMELPEGYGT
601 VVGEQAGLS GQQRORIAIA RALITNPRIL IFDEATSALD YESERAINQN
651 MQAICANRTV LIIAHLSTV KTAHRIIAMD KGRIVEAGTQ QELLAKPNGY
701 YRYLYDLQNG *

```

Computer analysis of this amino acid sequence gave the following results:

Homology with a predicted ORF from *N.meningitidis* (strain A)

40 ORF39 shows 100% identity over a 165aa overlap with an ORF (ORF39a) from strain A of *N. meningitidis*:

45
50
55
60

```

      orf39.pep      10      20      30
                        KFDFTWFIPIAVIKYRRLFFEVLVVSVVLQ
                        |||||
45 orf39a      AVLSFAEFSNRYSGKLILVASRASVLGSLAKFDFTWFIPIAVIKYRRLFFEVLVVSVVLQ
      110      120      130      140      150      160
                        40      50      60      70      80      90
      orf39.pep      FALITPLFFQVMDKVLVHRGFSTLDVVSVALLVVSLFEIVLGGLRITYLFAHTTSRIDVE
                        |||||
      orf39a      FALITPLFFQVMDKVLVHRGFSTLDVVSVALLVVSLFEIVLGGLRITYLFAHTTSRIDVE
      170      180      190      200      210      220
                        100      110      120      130      140      150
      orf39.pep      LGARLFRHLLSLPLSYFEHRRVGDTVARVRELEQIRNFLTQALTSVLDLAFSFIPLAVM
                        |||||
      orf39a      LGARLFRHLLSLPLSYFEHRRVGDTVARVRELEQIRNFLTQALTSVLDLAFSFIPLAVM
      230      240      250      260      270      280
      60 orf39.pep      WYYSSTLTWVVLASLXXXXXXXXXXXXXXXXXXXXXXXXXXXXXICANRTVLIIAHLSTV

```

orf39a |||||
 WYSSSTLTWVVLASLPAYAFWSAFISPIILRTRLNDKFARNADNQSFIVESITAVGTVKAM
 290 300 310 320 330 340

ORF39-1 and ORF39a show 99.4% identity in 710 aa overlap:

5	orf39-1.pep	MSIVSAPLPALSALIILAHYHGIAANPADIQHEFCTSAQSDLNETQWLLAAKSLGLKAKV
	orf39a	MSIVSAPLPALSALIILAHYHGIAANPADIQHEFCTSAQSDLNETQWLLAAKSLGLKAKV
10	orf39-1.pep	VRQPIKRLAMATLPALVWCDDGNHFILAKTDGEGEHAQFLIQDLVTNKSAVLSFAEFSNR
	orf39a	VRQPIKRLAMATLPALVWCDDGNHFILAKTDGGGEHAQYLIQDLTTNKSAVLSFAEFSNR
15	orf39-1.pep	YSGKLILVASRASVLGSLAKFDFTWFIPAVIKYRRLFFEVLVSVVLQLFALITPLFFQV
	orf39a	YSGKLILVASRASVLGSLAKFDFTWFIPAVIKYRRLFFEVLVSVVLQLFALITPLFFQV
20	orf39-1.pep	VMDKVLVHRGFSTLDVVSALLVVSLEIVLGGRLTYLFAHTTSRIDVELGARLFRHLLS
	orf39a	VMDKVLVHRGFSTLDVVSALLVVSLEIVLGGRLTYLFAHTTSRIDVELGARLFRHLLS
25	orf39-1.pep	LPLSYFEHRRVGDTVARVRELEQIRNFLTQGALTSVLDLAFSFIPLAVMWWYSSSTLTWV
	orf39a	LPLSYFEHRRVGDTVARVRELEQIRNFLTQGALTSVLDLAFSFIPLAVMWWYSSSTLTWV
30	orf39-1.pep	NQLAAYVASGFRVTKLAVVGQGVQLIQKLVTVATLWIGARLVIESKLTVGQLIAFNMLS
	orf39a	NQLAAYVASGFRVTKLAVVGQGVQLIQKLVTVATLWIGARLVIESKLTVGQLIAFNMLS
35	orf39-1.pep	GQVAAPVIRLAQLWQDFQQVGISVARLGDILNAPTENASSHLALPDIRGEITFEHVDFRY
	orf39a	GQVAAPVIRLAQLWQDFQQVGISVARLGDILNAPTENASSHLALPDIRGEITFEHVDFRY
40	orf39-1.pep	KADGRILIQDLNLRIRAGEVLGIVGRSGSGKSTLTKLQRLYVPEQGRVLVDGNDLALAA
	orf39a	KADGRILIQDLNLRIRAGEVLGIVGRSGSGKSTLTKLQRLYVPAQGRVLVDGNDLALAA
45	orf39-1.pep	PAWLRQVGVLQENVLLNRSIRDNIALTDTGMPLERIIEAAKLAGAHEFIMELPEGYGT
	orf39a	PAWLRQVGVLQENVLLNRSIRDNIALTDTGMPLERIIEAAKLAGAHEFIMELPEGYGT
50	orf39-1.pep	VVGEQGAGLSGGQRQRIAIARALITNPRILIFDEATSALDYESERAIMQNMQAICANRTV
	orf39a	VVGEQGAGLSGGQRQRIAIARALITNPRILIFDEATSALDYESERAIMQNMQAICANRTV
55	orf39-1.pep	LIIAHLSTVKTAHRIIAMDKGRIVEAGTQELLAKPNGYYRYLYDLQNGX
	orf39a	LIIAHLSTVKTAHRIIAMDKGRIVEAGTQELLAKPNGYYRYLYDLQNGX

The complete length ORF39a nucleotide sequence <SEQ ID 29> is:

	1	ATGTCTATCG	TATCCGCACC	GCTCCCGGCC	CTTTCGGCCC	TCATCATCCT
55	51	CGCCCATAC	CACGGCATTG	CCGCCAATCC	TGCCGATATA	CAGCATGAAT
	101	TTTGTACTTC	CGCACAGAGC	GATTTAAATG	AAACGCAATG	GCTGTAGCC
	151	GCCAAATCTT	TGGGATTGAA	GGCAAAGGTA	GTCCGCCAGC	CTATTAAACG
	201	TTTGGCTATG	CGCACTTTAC	CCGCATTGGT	ATGGTGTGAT	GACGGCAACC
	251	ATTTTATTTT	GGCTAAAACA	GACGGTGGGG	GTGAGCATGC	CCAATATCTA
60	301	ATACAGGATT	TAACACGAA	TAAGTCTGCG	GTATTGTCTT	TTGCCGAATT
	351	TTCTAACAGA	TATTCGGGCA	AACTGATATT	GGTTGCTTCC	CGCGCTTCGG
	401	TATTGGGCAG	TTTGGCAAAG	TTTGACTTTA	CCTGGTTTAT	TCCGGCGGTA
	451	ATCAAATACC	GCCGGTTGTT	TTTGAAGTA	TTGGTGGTGT	CGGTGGTGT
	501	GCAGCTGTTT	CGCCTGATTA	CGCCTCTGTT	TTTCCAAGTG	GTGATGGACA
65	551	AGGTGCTGGT	ACATCGGGGA	TTCTCTACTT	TGGATGTTGGT	GTCGGTGGCT
	601	TTGTTGGTGG	TGTCGCTGTT	TGAGATTGTG	TTGGGCGGTT	TGCGGACGTA
	651	TCTGTTTGCA	CATACGACTT	CACGTATTGA	TGTGGAATTG	GGCGCGCGTT

701 TGTTCGGCA TCTGCTTTCC CTGCCTTTAT CCTATTTTGA GCACAGACGA
 751 GTGGGTGATA CGGTGGCTCG GGTGCGGGAA TTGGAGCAGA TTCGCAATTT
 801 CTTGACCGGT CAGGCGCTGA CTTGCGTGTG GGATTGGCGG TTTTCGTTTA
 851 TCTTTCTGGC GGTGATGTGG TATTACAGCT CCACTCTGAC TTGGGTGGTA
 5 901 TTGGCTTCGT TGCCTGCCTA TCGGTTTTGG TCGGCATTTA TCAGTCCGAT
 951 ACTGCGGACG CGTCTGAACG ATAAGTTTCG CCGCAATGCA GACAACCACT
 1001 CGTTTTTAGT AGAAAGCATC ACTGCGGTGG GTACGGTAAA GCGATGGCG
 1051 GTGGAGCCGC AGATGACGCA GCGTTGGGAC AATCAGTTGG CGGCTTATGT
 1101 GGCTTCGGGA TTTGCGGTAA CGAAGTTGGC GGTGGTCGGC CAGCAGGGGG
 10 1151 TGCAGCTGAT TCAGAAGCTG GTGACGGTGG CGACGTTGTG GATTGGCGCA
 1201 CCGCTGGTAA TTGAGAGCAA GCTGACGGTG GGCAGCTGA TTGCGTTTAA
 1251 TATGCTCTCG GGACAGGTGG CGGCGCTGT TATCCGTTG GCGCAGTTGT
 1301 GGCAGGATT CCAGCAGGTG GGGATTTTCG TGGCGCGTT GGGGGATATT
 1351 CTGAATGCGC CGACCGAGAA TCGCTCTTCG CATTTGGCTT TGCCCGATAT
 1401 CCGGGGGGAG ATTACGTTTC AACATGTCGA TTTCGCTAT AAGGCGGACG
 15 1451 GCAGGCTGAT TTTGCAGGAT TTGAACCTGC GGATTCGGGC GGGGGAAGTG
 1501 CTGGGGATTG TGGGACGTTT GGGGTCGGGC AAATCCACAC TCACCAAAAT
 1551 GGTGCAGCGT CTGTATGTAC CGGCGCAGGG ACGGGTGTG GTGGACGGCA
 1601 ACGATTTGGC TTTGGCCGCT CTGCTTGGC TGGCGCGCA GGTCGGCGTG
 20 1651 GTCTTGCAAG AGAATGTGCT GCTCAACGCG AGCATAACG ACAATATCGC
 1701 GCTGACGGAT ACGGGTATGC CGCTGGAACG CATTATCGAA GCAGCCAAAC
 1751 TGGCGGGCGC ACACGAGTTT ATTATGGAGC TGCCGGAAGG CTACGGCAAC
 1801 GTGGTGGGCG AACAAGGGGC CGGCTTGTTC GCGGACAGC GGCAGCGTAT
 1851 TGGGATTGCC CGCGCGTTAA TCACCAATCC GCGCATTCG ATTTTGTATG
 25 1901 AAGCCACCAG CGCGCTGGAT TATGAAAGTG AACGAGCGAT TATGCAGAAC
 1951 ATGCAGGCCA TTTGCGCCAA CCGGACGGTG CTGATTATCG CCCACCGTCT
 2001 GTCCACTGTT AAAACGGCAC ACCGGATCAT TGCCATGGAT AAAGGCAGGA
 2051 TTGTGGAAGC GGAACACAG CAGGAATTGC TGGCGAAGCC GAACGGATAT
 2101 TACCGCTATC TGTATGATT ACAGAACGGG TAG

30 This encodes a protein having amino acid sequence <SEQ ID 30>:

1 MSIVSAPLPA LSALIILAHY HGIAANPADI QHEFCTSAQS DLNETQWLLA
 51 AKSLGLKAKV VRQPIKRLAM ATLPALVWCD DGNHFILAKT DGGGEHAQYL
 101 IQDLTTNKSA VLSFAEFSNR YSGKLILVAS RASVLGSLAK FDTWFI PAV
 151 IKYRRLFFEV LVSVVLQLF ALITPLFFQV VMDKVLVHRG FSTLDVVSVA
 35 201 LLVVSLEFIV LGLRLTYLFA HTTSRIDVEL GARLFRHLLS LPLSYFEHRR
 251 VGDTVARVRE LEQIRNFLTG QALTSVLDLA FSFIFLAVMW YYSSTLTWVV
 301 LASLPAYAFW SAFISPIIRT RLNDKFARNA DNQSFLVESI TAVGTVKAMA
 351 VEPQMTQRWD NQLAAYVASG FRVTKLAVVG QQGVQLIQLK VTATLWIGA
 401 RLVIKSLTV GQLIAFNMLS GQVAPVIRL AQLWQDFQV GISVARLGDI
 451 LNAPTENASS HLALPDIRGE ITFEHVDFRY KADGRLLIQD LNLIRAGEV
 501 LGIVGRSGSG KSTLTCLVQR LYVPAQGRVL VDGNDLALAA PAWLRRQGV
 551 VLQENVLLNR SIRDNIATD TGMPLERIE AAKLAGAHEF INELPEGYGT
 601 VVGEQAGLS GGQRQRIIA RALITNPRIL IFDEATSALD YESERAIMQN
 651 MQAICANRTV LIIAHLSTV KTAHRIIAMD KGRIVEAGTQ QELLAKPNGY
 45 701 YRYLYDLQNG *

ORF39a is homologous to a cytolysin from *A. pleuropneumoniae*:

sp|P26760|RT1B_ACTPL RTX-I TOXIN DETERMINANT B (TOXIN RTX-I SECRETION ATP-BINDING PROTEIN) (APX-IB) (HLY-IB) (CYTOLYSIN IB) (CLY-IB)
 50 >gi|97137|pir|D43599 cytolysin IB - Actinobacillus pleuropneumoniae (serotype 9)
 >gi|38944 (X61112) ClyI-B protein [Actinobacillus pleuropneumoniae] Length = 707
 Score = 931 bits (2379), Expect = 0.0
 Identities = 472/690 (68%), Positives = 540/690 (77%), Gaps = 3/690 (0%)
 Query: 20 YHGIAANPADIQHEFCTSAQSDLNQWXXXXXXXXXXXXXVVRQPIKRLAMATLPALVWC 79
 YH IA NP +++H+F + L+ T W V++ I RLA LPALVW
 Sbjct: 20 YHNIHAVNPEELKHKFDLEGKG-LDLTAWLLAAKSLELKAKQVKKIDRLAFIALPALVWR 78
 Query: 80 DDGNHFILAKTDGGGEHAQYLIQDLTTNKSAVLSFAEFSNRYSGKLILVASRASVLGSLA 139
 +DG HFIL K D E +YLI DL T+ +L AEF + Y GKLILVASRAS++G LA
 60 Sbjct: 79 EDGKHFIKIDN--EAKKYLIQDLTETHNPRILEQAEFESLYQGLILVASRASIVGKLA 136
 Query: 140 KFDFTWFI PAVIKYRXXXXXXXXXXXXXXXXXITPLFFQVMDKVLVHRGFXXXXXXXXX 199
 KFDFTWFI PAVIKYR+ ITPLFFQVMDKVLVHRGF
 Sbjct: 137 KFDFTWFI PAVIKYRKIFETLIVSIFLQIFALITPLFFQVMDKVLVHRGFSTLNVITV 196
 65 Query: 200 XXXXXXXFEIVLGLRLTYLFAHTTSRIDVELGARLFRHLLSLPLSYFEHRRVGDTVARVR 259

FEIVL GLRTY+FAH+TSRIDVELGARLFRHLL+LP+SYFE+RRVGD TVARVR
 Sbjct: 197 ALAIVVLFEIVLNLRTYIFAHSTSRIDVELGARLFRHLLALPISYFENRRVGVOTVARVR 256

5 Query: 260 ELEQIRNFLTGOALTSVLDLAFSFI FLAVMWWYSSSTLTWVVLASLPAYAFWSAFISPILR 319
 EL+QIRNFLTGOALTSVLDL FSFIF AVMWYYS LT V+L SLP Y WS FISPILR
 Sbjct: 257 ELDQIRNFLTGOALTSVLDLMSFIFFAVMWWYSPKLT LVILGSLPFFYMGWSIFISPILR 316

10 Query: 320 TRLNDFARNADNQSFLVESITAVGTVKAMAVEPQMTQRWDNQLAAYVASGFRVTKLAVV 379
 RL++KFAR ADNQSFLVES+TA+ T+KA+AV PQMT WD QLA+YV++GFRVT LA +
 Sbjct: 317 RRLDEKFARGADNQSFLVESVTAINTIKALAVTPQMTNTWDKQLASYVSAGFRVTTLATI 376

15 Query: 380 GQQGVQLIQKLVTVATLWIGARLVIESKLTVGQLIAFNMLSGQVAAPVIRLAQLWQDFQQ 439
 GQQGVQ IQK+V V TLW+GA LVI L++GQLIAFNMLSGQV APVIRLAQLWQDFQQ
 Sbjct: 377 GQQGVQFIQKVMVITLWLGAHLVISGDL SIGQLIAFNMLSGQVIAPVIRLAQLWQDFQQ 436

20 Query: 440 VGISVARLGDILNAPTENASSHLALPDIRGEITFEHVDFRYKADGRLLIQLDLNLRIRAGE 499
 VGISV RLGD+LN+PTE+ LALP+I+G+ITF ++ FRYK D +IL D+NL I+ GE
 Sbjct: 437 VGISVTRLGDVLNSPTESYQGLALPEIKGDITFRNIRFRYKPDAPVILNDVNLSIQQGE 496

25 Query: 500 VLGIVGRSGSGKSTLTCLKVQRLVYVPAQGRVLVDGNDLALAAPAWLRRQGVVVLQENVLLN 559
 V+GIVGRSGSGKSTLTCLK+QR Y+P G+VL+DG+DLALA P WLRQGVVVLQ+NVLLN
 Sbjct: 497 VIGIVGRSGSGKSTLTCLKIQRFYIPENGQVLDGHDALADPNWLRQGVVVLQDNVLLN 556

30 Query: 560 RSIRDNIALDTGMPLERIIEAAKLAGAHEFIMELPEGYGTVVGEQAGLSGGQRQRIAI 619
 RSIRDNIAL D GMP+E+I+ AAKLAGAHEFI EL EGY T+VGEQAGLSGGQRQRIAI
 Sbjct: 557 RSIRDNIALADPGMPMEKIVHAAKLAGAHEFISELREGYNTIVGEQAGLSGGQRQRIAI 616

35 Query: 620 ARALITNPRILIFDEATSALDYESERAIMQNMQAICANRTVLIIAHRLSTVKT AHRIIAM 679
 ARAL+ NP+ILIFDEATSALDYESE IM+NM IC RTV+IIAHRLSTVK A RII M
 Sbjct: 617 ARALVNNPKILIFDEATSALDYESEHIIMRNMHQICKGRTVIIIAHRLSTVKNADRIIVM 676

Query: 680 DKGRIVEAGTQOELLAKENGYYRYLYDLQN 709
 +KG+IVE G +ELLA PNG Y YL+ LQ+
 Sbjct: 677 EKGQIVEQGHKELLADPNGLYHYLHQLQS 706

Homology with the HlyB leucotoxin secretion ATP-binding protein of *Haemophilus actinomycescomitans* (accession number X53955)

ORF39 and HlyB protein show 71% and 69% amino acid identity in 167 and 55 overlap at the N- and C-terminal regions, respectively:

40 Orf39 1 KFDFTWFIPAVIKYRRXXXXXXXXXXXXXXXXXITPLFFQVMDKVLVHRGFXXXXXXXXX 60
 KFDFTWFIPAVIKYR+ ITPLFFQVMDKVLVHRGF
 HlyB 137 KFDFTWFIPAVIKYRKIFETLIVSIFLQIFALITPLFFQVMDKVLVHRGFSTLNVITV 196

45 Orf39 61 XXXXXXFEIVLGGRLTYLFAHTTSRIDVELGARLFRHLLSLPLSYFEHRRVGD TVARVR 120
 FEI+LGGRLTY+FAH+TSRIDVELGARLFRHLL+LP+SYFE RRVGD TVARVR
 HlyB 197 ALAIVVLFEIILGGRLTYVFAHSTSRIDVELGARLFRHLLALPISYFEARRVGD TVARVR 256

50 Orf39 121 ELEQIRNFLTGOALTSVLDLAFSFI FLAVMWWYSSSTLTWVVLASLIC 167
 EL+QIRNFLTGOALTS+LDL FSFIF AVMWYYS LT VVL SL C
 HlyB 257 ELDQIRNFLTGOALTSILDLLFSFIFFAVMWWYSPKLT LVVLGSLPC 303

//

55 Orf39 166 ICANRTVLIIAHRLSTVKT AHRIIAMDKGRIVEAGTQOELLANXNGYYRYLYDLQ 220
 IC NRTVLIIAHRLSTVK A RII MDKG I+E G QELL + G Y YL+ LQ
 HlyB 651 ICQNRVLIIAHRLSTVKNADRIIVMDKGEIIEQGHQELLKDEKGLYSYLHQLQ 705

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 7

60 The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 31>

```

1  ATGAAATACT TGATCCGCAC CGCCTTACTC GCAGTCGCAG CCGCCGGCAT
51  CTACGCCTGC CAACCGCAAT CCGAAGCCGC AGTGCAAGTC AAGGCTGAAA
101 ACAGCCTGAC CGCTATGCGC TTAGCCGTCG CCGACAAACA GGCAGAGATT
151 GACGGGTGA ACGCCCAAk sGACCCGAA ATCAGA...

```

- 5 This corresponds to the amino acid sequence <SEQ ID 32; ORF52>:

```

1  MKYLIRTALL AVAAAGIYAC QPQSEAAVQV KAENSLTAMR LAVADKQAEI
51  DGLNAQXDAE IR..

```

Further work revealed the complete nucleotide sequence <SEQ ID 33>:

```

10 1  ATGAAATACT TGATCCGCAC CGCCTTACTC GCAGTCGCAG CCGCCGGCAT
    51  CTACGCCTGC CAACCGCAAT CCGAAGCCGC AGTGCAAGTC AAGGCTGAAA
    101 ACAGCCTGAC CGCTATGCGC TTAGCCGTCG CCGACAAACA GGCAGAGATT
    151 GACGGGTGA ACGCCCAAAT CGACGCCGAA ATCAGACAAC GCGAAGCCGA
    201 AGAATTGAAA GACTACCGAT GGATACACGG CGACGCCGAA GTGCCGGAGC
    251 TGGAAAATG A

```

- 15 This corresponds to the amino acid sequence <SEQ ID 34; ORF52-1>:

```

1  MKYLIRTALL AVAAAGIYAC QPQSEAAVQV KAENSLTAMR LAVADKQAEI
51  DGLNAQIDAE IRQREAEELK DYRWIHGDAE VPELEK*

```

Computer analysis of this amino acid sequence predicts a prokaryotic membrane lipoprotein lipid attachment site (underlined).

- 20 ORF52-1 (7kDa) was cloned in the pGex vectors and expressed in *E.coli*, as described above. The products of protein expression and purification were analyzed by SDS-PAGE. Figure 4A shows the results of affinity purification of the GST-fusion. Figure 4B shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF52-1.

- Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could
 25 be useful antigens for vaccines or diagnostics.

Example 8

The following DNA sequence was identified in *N.meningitidis* <SEQ ID 35>

```

30 1  ATGGTTATCG GAATATTACT CGCATCAAGC AAGCATGCTC TTGTCATTAC
    51  TCTATTGTTA AATCCCGTCT TCCATGCATC CAGTTGCGTA TCGCGTTsGG
    101 CAATACGGAA TAAAAtCTGC TGTTCGTCTT TGGCTAAATT TGCCAAATTG
    151 TTTATTGTTT CTTTAGGaGC AGCTTGCTTA GCCGCCTTCG CTTTCGACAA
    201 CGCCCCACA GCGCTTCCC AAGCgTTGCC TACCGTTACC GCACCCGTGG
    251 CGATTCCCGC GCCCGCTTCG GCAGCCTGA

```

This corresponds to the amino acid sequence <SEQ ID 36; ORF56>:

```

35 1  MVIGILLASS KHALVITLLL NPVFHASSCV SRXAIRNKIC CSALAKFAKL
    51  FIVSLGAACL AAFAFDNAPT GASQALPTVT APVAIPAPAS AA*

```

Further work revealed the complete nucleotide sequence <SEQ ID 37>:

```

1  ATGGCTTGTA CAGGTTTGAT GGTtTTTCCG TTAATGGTTA TCGGAATATT

```

51 ACTTGCATCA AGCAAGCCTG CTCCTTTCCT TACTCTATTG TTAAATCCCG
 101 TCTTCCATGC ATCCAGTTGC GTATCGCGTT GGGCAATACG GAATAAAATC
 151 TGCTGTTCTG CTTTGGCTAA ATTTGCCAAA TTGTTTATTG TTTCTTTAGG
 201 AGCAGCTTGC TTAGCCGCCT TCGCTTTCGA CAACGCCCCC ACAGGCGCTT
 5 251 CCAAGCGTT GCCTACCGTT ACCGCACCCG TGGCGATTCC CGCGCCCGCT
 301 TCGGCAGCCT GA

This corresponds to the amino acid sequence <SEQ ID 38; ORF56-1>:

1 MACTGLMVFP LMVIGILLAS SKPAPFLTLL LNPVFHASSC VSRWAIRNKI
 51 CCSALAKFAK LFIVSLGAAC LAFAFDNAP TGASQALPTV TAPVAIPAPA
 10 101 SAA*

Computer analysis of this amino acid sequence predicts a leader peptide (underlined) and suggests that ORF56 might be a membrane or periplasmic protein.

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

15 Example 9

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 39>

1 ATGTTCAGTA TTTTAAATGT GTTCTTCAT TGTATTCTGG CTTGTGTAGT
 51 CTCTGGTGAG ACGCCTACTA TATTTGGTAT CCTTGCTCTT TTTTACTTAT
 101 TGTATCTTTC TTATCTTGCT GTTTTAAAGA TTTTCTTTTC TTTTTCCTTA
 20 151 GACAGAGTTT CACTCCGGTC TCCAGGCTG GAGTGCAAAT GGCATGACCC
 201 TTTGGCTCAC TGGCTCACGG CCACTTCTGC TATTCTGCCG CCTCAGCCTC
 251 CAGGG...

This corresponds to the amino acid sequence <SEQ ID 40; ORF63>:

1 MFSILNVFLH CILACVVSGE TPTIFGILAL FYLLYLSYLA VFKIFFSFFEL
 25 51 DRVSLRSPRL ECKWHDPLAH WLTATSAILP PQPPG...

Computer analysis of this amino acid sequence predicts a transmembrane region.

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 10

30 The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 41>

1 ..GTGCGGACGT GGTGGTTTT TTGGTTGCAG CGTTTGAAAT ACCCGTTGTT
 51 GCTTTGGATT GCGGATATGT TGCTGTACCG GTTGTGGGC GGCGCGGAAA
 101 TCGAATGCGG CCGTTGCCCT GTGCCGCCGA TGACGGATTG GCAGCATTTT
 151 TTGCCGCGCA TGGGAACGGT GTCGGCTTGG GTGGCGGTGA TTTGGGCATA
 35 201 CCTGATGATT GAAAGTGAAA AAAACGGAAG ATATTGA

This corresponds to the amino acid sequence <SEQ ID 42; ORF69>:

1 ..VRTWLVEWLQ RLKYPLLLWI ADMLLYRLLG GAEIECGRCP VPPMTDQHF
 51 LPAMGTVSAW VAVIWAYLMI ESEKNGRY*

Computer analysis of this amino acid sequence predicts a transmembrane region.

A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

ORF69 shows 96.2% identity over a 78aa overlap with an ORF (ORF69a) from strain A of *N.*

5 *meningitidis*:

```

      10      20      30      40      50      60
orf69.pep  VRTWL VFWLQRLKYPLLLWIADMLLYRLLGGAEIECGRCPVPPMTDWQHFLPAMGTVSAW
            |||||
orf69a     VRTWL VFWLQRLKYPLLLCIADMLLYRLLGGAEIECGRCPVPPMTDWQHFLPTMGTVAAW
10          10      20      30      40      50      60

      70      79
orf69.pep  VAVIWAYLMIESEKNGRYX
            |||||
15 orf69a   VAVIWAYLMIESEKNGRYX
            70

```

The ORF69a nucleotide sequence <SEQ ID 43> is:

```

      1  GTGCGGACGT  GGTGGTTTT  TTGGTTGCAG  CGTTTGAAAT  ACCCGTGTGT
20  51  GCTTTGTATT  GCGGATATGC  TGCTGTACCG  GTTGTGGGC  GGCGCGGAAA
101  TCGAATGCGG  CCGTTGCCCT  GTACCGCCGA  TGACGGATTG  GCAGCATTTT
151  TTGCCGACGA  TGGGAACGGT  GGCGGCTTGG  GTGGCGGTGA  TTTGGGCATA
201  CCTGATGATT  GAAAGTGAAA  AAAACGGAAG  ATATTGA

```

This encodes a protein having amino acid sequence <SEQ ID 44>:

```

      1  VRTWL VFWLQ  RLKYPLLLCI  ADMLLYRLLG  GAEIECGRCP  VPPMTDWQHF
25  51  LPTMGTVAAW  VAVIWAYLMI  ESEKNGRY*

```

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 11

30 The following DNA sequence was identified in *N.meningitidis* <SEQ ID 45>

```

      1  ATGTTTCAA  ATTTTGATT  GGGCGTGTC  CTGCTTGCCG  TCCTCCCCGT
51  GCTGCCCTCC  ATTACCGTCT  CGCACGTGGC  GCGCGGCTAT  ACGGCGCGCT
101  ACTGGGGAGA  CAACACTGCC  GAACAATACG  GCAGGCTGAC  ACTGAACCCC
151  CTGCCCCATA  TCGATTGGT  CGGCACAATC  ATCgTACCGC  TGCTTACTTT
35  201  GATGTTACAG  CCTTCCTGT  TCGGCTGGGC  GCGTCCGATT  CCTATCGATT
251  CGCGCAACTT  CCGCAACCCG  cGCCTTGCTT  GCGTTCGCGT  TGCCGCGTCC
301  GGCCCGCTGT  CGAATCTAGC  GATGGCTGTW  CTGTGGGGCG  TGGTTTGGT
351  GCTGACTCCG  TATGTCGGCG  GGGCGTATCA  GATGCCGTTG  GCTCAAATGG
401  CAAACTACGG  TATTCTGATC  AATGCGATTC  TGTTCCGCGT  CAACATCATC
40  451  CCCATCCTGC  CTTGGGACGG  CGGCATTTTC  ATCGACACCT  TCCTGTCGGC
501  GAAATATTTC  CAAGCGTTCC  GCAAAATCGA  ACCTTATGGG  ACGTGGATTA
551  TCTACTGCT  GATGCTGACC  sGGGTTTGG  GTGCGTTTAT  wGCACCGATT
601  sTGCGGmTGc  GTGATTGCrT  TTGTGCAGAT  GTwCGTCTGA  CTGGCTTTCA
651  GACGGCATAA

```

45 This corresponds to the amino acid sequence <SEQ ID 46; ORF77>:

1 MFQNFDLGVF LLAVLPVLPS ITVSHVARGY TARYWGDNTA EQYGRRLTLNP
 51 LPHIDLVGTI IVPLLTLMFT PFLFGWARPI PIDSRNFRNP RLAWRCVAAS
 101 GPLSNLAMAV LWGVVLVLTTP YVGGAYQMPL AQMANYGILI NAILFALNII
 151 PILPWDGGIF IDTFLSAKYS QAFRKIEPYG TWIILLMLT XVLGAFIPI
 201 XRXRDCXCAD VRLTGFQTA*

Further work revealed the complete nucleotide sequence <SEQ ID 47>:

1 ATGTTTCAAA ATTTTGATTT GGGCGTGTCTT CTGCTTGCCG TCCTGCCCGT
 51 GCTGCTCTCC ATTACCGTCA GGGAGGTGGC GCGCGGCTAT ACGGCGCGCT
 101 ACTGGGGAGA CAACACTGCC GAACAATACG GCAGGCTGAC ACTGAACCCC
 151 CTGCCCCATA TCGATTTGGT CGGCACAATC ATCGTACCGC TGCTTACTTT
 201 GATGTTACG CCCTTCTGT TCGGCTGGGC GCGTCCGATT CCTATCGATT
 251 CGCGCAACTT CCGCAACCCG CGCCTTGCTT GCGGTGCGT TGCCGCGTCC
 301 GGGCCGCTGT CGAATCTAGC GATGGCTGTT CTGTGGGGCG TGGTTTGGT
 351 GCTGACTCCG TATGTCGGCG GGGCGTATCA GATGCCGTTG GCTCAAATGG
 401 CAACTACGG TATTCTGATC AATGCGATTG TGTTCCGCGT CAACATCATC
 451 CCCATCCTGC CTTGGGACGG CGGCATTTTC ATCGACACCT TCCTGTGCGC
 501 GAAATATTCG CAAGCGTTCC GCAAAATCGA ACCTTATGGG ACGTGGATTA
 551 TCCTACTGCT GATGCTGACC GGGGTTTGG GTGCGTTTAT TGCACCGATT
 601 GTGCGGCTGG TGATTGCGTT TGTGCAGATG TTCGTCTGA

20 This corresponds to the amino acid sequence <SEQ ID 48; ORF77-1>:

1 MFQNFDLGVF LLAVLPVLLS ITVREVARGY TARYWGDNTA EQYGRRLTLNP
 51 LPHIDLVGTI IVPLLTLMFT PFLFGWARPI PIDSRNFRNP RLAWRCVAAS
 101 GPLSNLAMAV LWGVVLVLTTP YVGGAYQMPL AQMANYGILI NAILFALNII
 151 PILPWDGGIF IDTFLSAKYS QAFRKIEPYG TWIILLMLT GVLGAFIPI
 201 VRLVIAFVQM FV*

Computer analysis of this amino acid sequence reveals a putative leader sequence and several transmembrane domains.

A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

30 ORF77 shows 96.5% identity over a 173aa overlap with an ORF (ORF77a) from strain A of *N.meningitidis*:

		10	20	30	40	50	60
orf77.pep		MFQNFDLGVFLLAVLPVLP	SITVSHVARGY	TARYWGDNTA	EQYGRRLTLN	NPLPHIDLVG	TI
35	orf77a			RGYTARYWGDNTA	EQYGRRLTLN	NPLPHIDLVG	TI
				10	20	30	
		70	80	90	100	110	120
40	orf77.pep	IVPLLTLMFT	PFLFGWARPI	PIDSRNFRNP	RLAWRCVAAS	GPLSNLAMAV	LWGVVLVLT
	orf77a	IVPLLTLMFT	PFLFGWARPI	PIDSRNFRNP	RLAWRCVAAS	GPLSNLAMAV	LWGVVLVLT
		40	50	60	70	80	90
		130	140	150	160	170	180
45	orf77.pep	YVGGAYQMPL	AQMANYGILI	NAILFALNII	PILPWDGGIF	IDTFLSAKYS	QAFRKIEPYG
	orf77a	YVGGAYQMPL	AQMANYXILI	NAILXALNII	PILPWDGGIF	IDTFLSAKXS	QAFRKIEPYG
		100	110	120	130	140	150
50	orf77.pep		190	200	210	220	
	orf77a		TWIILLMLT	XVLGAFIPI	XRXRDCXCAD	VRLTGFQTA	
			160	170	180		

ORF77-1 and ORF77a show 96.8% identity in 185 aa overlap:

```

      10      20      30      40      50      60
orf77-1.pep MFQNFDLGVFLAVLPVLLSITVREVARGYTARYWGDNTAEQYGRLLTNPLPHIDLVGTT
5  orf77a      RGYTARYWGDNTAEQYGRLLTNPLPHIDLVGTT
      10      20      30

      70      80      90      100     110     120
orf77-1.pep IVPLLTLMFTPFELFGWARPIPIDSRNFRNPRLAWRCVAASGPLSNLAMAVLWGVVLVLTTP
10 orf77a      IVPLLTLMFTPFELFGWARPIPIDSRNFRNPRLAWRCVAASGPLSNLAMAVLWGVVLVLTTP
      40      50      60      70      80      90

      130     140     150     160     170     180
orf77-1.pep YVGGAYQMPLAQMANYGILINAILFALNIIPILPWDGGIFIDTFLSAKYSQAFRKIEPYG
15 orf77a      YVGGAYQMPLAQMANYYILINAILXALNIIPILPWDGGIFIDTFLSAKXSQAFRKIEPYG
      100     110     120     130     140     150

      190     200     210
orf77-1.pep TWIILLMLTGVLGAFIPIVRLVIAFVQMFVX
20 orf77a      TWIIXLLMLTGVLGAXIPIVQLVIAFVQMFVX
      160     170     180

```

A partial ORF77a nucleotide sequence <SEQ ID 49> was identified:

```

      1  ..CGCGGCTATA CAGCGCGCTA CTGGGGTGAC AACACTGCCG AACAAATACGG
51  CAGGCTGACA CTGAACCCCC TGCCCCATAT CGATTGGTC GGCACAATCA
101 TCGTACCGCT GCTTACTTTG ATGTTTACGC CCTTCCTGTT CGGCTGGGCG
151 CGTCCGATTG CTATCGATTG GCGCAACTTC CGCAACCCGC GCCTTGCCTG
201 GCGTTGCGTT GCCGCGTCCG GCCCGCTGTC GAATCTGGCG ATGGCTGTTC
251 TGTGGGGCGT GGTTTTGGTG CTGACTCCGT ATGTCGGTGG GCGGTATCAG
301 ATGCCGTTGG CNCAATGGC AAATACNNN ATTCTGATCA ATGCGATTCT
351 GTNCGCGCTC AACATCATCC CCATCCTGCC TTGGGACGGC GGCATTTTCA
401 TCGACACCTT CCTGTGCGCN AAATANTCGC AAGCGTTCCG CAAAATCGAA
35 451 CCTTATGGGA CGTGGATTAT CCNGCTGCTT ATGCTGACCG GGGTTTGGG
501 TCGGTNTATT GCACCGATTG TGCAGCTGGT GATTGCGTTT GTGCAGATGT
551 TCGTCTGA

```

This encodes a protein having amino acid sequence <SEQ ID 50>:

```

40      1  ..RGYTARYWGD NTAEQYGRLL LNPLPHIDLV GTIIVPLLT MFTPFELFGWA
51  RPIPIDSRNF RNPRLAWRCV AASGPLSNLA MAVLWGVVLV LTPYVGGAYQ
101 MPLAQMANXX ILINAILXAL NIIPILPWDG GIFIDTFLSA KXSQAFRKIE
151 PYGTWIIIXLL MLTGVLGAXI APIVQLVIAF VQMFV*

```

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 12

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 51>

```

      1  ATGAACCTGA TTACACGTTA CATCATCCGT CAAATGGCGG TTATGGCGGT
51  TTACGCGCTC CTTGCCTTCC TCGCTTTGTA CAGCTTTTTT GAAATCCTGT
101 ACGAAACCGG CAACCTCGGC AAAGGCAGTT ACGGCATATG GGAATGCTG
50 151 GGCTACACCG CCCTCAAATG GCCCGCCGCG GCCTACGAAC TGATTCCCCT
201 CGCCGTCCTT ATCGGCGGAC TGGTCTCCCT CAGCCAGCTT GCCGCGGCA
251 GCGAACTGAC CGTCATCAA GGCAGCGGCA TGAGCACCAA AAAGCTGCTG
301 TTGATTCTGT CGCAGTTCGG TTTTATTTT GCTATTGCCA CCGTCGCGCT
55 351 CGGCGAATGG GTTGCGCCCA CACTGAGCCA AAAAGCCGAA AACATCAAAG

```

401 CCGCGGCCAT CAACGGCAAA ATCAGCACCG GCAATACCGG CCTTTGGCTG
 451 AAAGAAAAAA ACAGCGTGAT CAATGTGCGC GAAATGTTGC CCGACCAT..

This corresponds to the amino acid sequence <SEQ ID 52; ORF112>:

5 1 MNLSRYIIR QMAVMVYAL LAFLALYSFF EILYETGNLG KGSYGIWEML
 51 GYTALKMPAR AYELIPLAVL IGGLVLSLSQL AAGSELTVIK ASGMSTKKLL
 101 LILSQFGFIF AIATVALGEW VAPTLSQKAE NIKAAAINGK ISTGNTGLWL
 151 KEKNSVINVR EMLPDH...

Further work revealed further partial nucleotide sequence <SEQ ID 53>:

10 1 ATGAACCTGA TTTCACGTTA CATCATCCGT CAAATGGCGG TTATGGCGGT
 51 TTACGCGCTC CTTGCCTTCC TCGCTTTGTA CAGCTTTTTT GAAATCCTGT
 101 ACGAAACCGG CAACCTCGGC AAAGGCAGTT ACGGCATATG GGAAATGCTG
 151 gGCTACACCG CCCTCAAAAT GCCGCGCCGC GCCTACGAAC TGATTCCTCT
 201 CGCCGTCTT ATCGGCGGAC TGGTCTCCCT CAGCCAGCTT GCCGCGGCA
 251 GCGAACTGAC CGTCATCAA GCCAGCGGCA TGAGCACCAA AAAGCTGCTG
 15 301 TTGATTCTGT CGCAGTTCGG TTTTATTTT GCTATTGCCA CCGTCGCGCT
 351 CGGCGAATGG GTTGCGCCCA CACTGAGCCA AAAAGCCGAA AACATCAAAG
 401 CCGCGGCCAT CAACGGCAAA ATCAGCACCG GCAATACCGG CCTTTGGCTG
 451 AAAGAAAAAA ACAGCTKAT CAATGTGCGC GAAATGTTGC CCGACCATAC
 501 GCTTTTGGGC ATCAAAATTT GGGCGCGCAA CGATAAAAC GAATTGGCAG
 20 551 AGGCAGTGGA AGCCGATTCC GCCGTTTGA ACAGCGACGG CAGTTGGCAG
 601 TTGAAAAACA TCCGCGCAG CACGCTTGGC GAAGACAAAG TCGAGGCTCT
 651 TATTGCGGCT GAAGAAACT GGCCGATTTC CGTCAAACGC AACCTGATGG
 701 ACGTATTGCT CGTCAAACCC GACCAAATGT CCGTCGGCGA ACTGACCACC
 751 TACATCCGCC ACCTCCAAA CAACAGCCAA AACACCCGAA TCTACGCCAT
 25 801 CGCATGGTGG CGCAAATTGG TTTACCCCGC CGCAGCCTGG GTGATGGCGC
 851 TCGTCGCCTT TGCCTTTACC CCGCAAACCA CCGCCACGG CAATATGGGC
 901 TTAAACTCT TCGGCGGCAT CTGTsTCGGA TTGCTGTTCC ACCTTGCCGG
 951 ACGGCTCTT GGGTTTACCA GCCAACTCGG...

This corresponds to the amino acid sequence <SEQ ID 54; ORF112-1>:

30 1 MNLSRYIIR QMAVMVYAL LAFLALYSFF EILYETGNLG KGSYGIWEML
 51 GYTALKMPAR AYELIPLAVL IGGLVLSLSQL AAGSELTVIK ASGMSTKKLL
 101 LILSQFGFIF AIATVALGEW VAPTLSQKAE NIKAAAINGK ISTGNTGLWL
 151 KEKNSXINVR EMLPDHTLLG IKIWARNOKN ELAEAVEADS AVLNSDGSWQ
 201 LKNIRRTLIG EDKVEVSIAA EENWPISVKR NLMDVLLVKP DOMSVGELTT
 35 251 YIRHLQNNNSQ NTRIYAIWW RKLVPAAAW VMALVAFAET PQTRHGNMG
 301 LKLEGGICXG LLEHLAAGRLF GFTSQL...

Computer analysis of this amino acid sequence predicts two transmembrane domains.

A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

40 ORF112 shows 96.4% identity over a 166aa overlap with an ORF (ORF112a) from strain A of *N.meningitidis*:

		10	20	30	40	50	60
orfl12.pep		MNLSRYIIRQMAVMVYALLAFLALYSFFEILYETGNLGKGSYGIWEMLGYTALKMPAR					
45	orfl12a						
		10	20	30	40	50	60
		MNLSRYIIRQMAVMVYALLAFLALYSFFEILYETGNLGKGSYGIWEMXGYTALKMXAR					
		70	80	90	100	110	120
50	orfl12.pep	AYELIPLAVLIGGLVLSLSQLAAGSELTVIKASGMSTKKLLLILSQFGFIFAIATVALGEW					
	orfl12a						
		70	80	90	100	110	120
		AYELMPLAVLIGGLVLSXSQLAAGSELXVIKASGMSTKKLLLILSQFGFIFAIATVALGEW					

```

              130      140      150      160
orfl12.pep  VAPTLSQKAENIKAAAINGKISTGNTGLWLKEKNSVINVREMLPDH
              |||
5  orfl12a   VAPTLSQKAENIKAAAINGKISTGNTGLWLKEKNSIINVREMLPDHTLLGIKIWARNDKN
              130      140      150      160      170      180
orfl12a     ELAEAVEADSAVLNSDGSWQLKNIRRLSTLGEDKVEVSIAAEEXWPISVKNRLMDVLLVKP
              190      200      210      220      230      240

```

A partial ORF112a nucleotide sequence <SEQ ID 55> was identified:

```

10      1  ATGAACCTGA  TTTACGTTA  CATCATCCGT  CAAATGGCGG  TTATGGCGGT
      51  TTACGCGCTC  CTTGCCTTCC  TCGCTTTGTA  CAGCTTTTTT  GAAATCCTGT
     101  ACGAAACCGG  CAACCTCGGC  AAAGGCAGTT  ACGGCATATG  GGAATGNTG
     151  GGNACACCG  CCCTCAAAAT  GNCCGCCCGC  GCCTACGAAC  TGATGCCCTT
     201  CGCCGTCCTT  ATCGGCGGAC  TGGTCTCTNT  CAGCCAGCTT  GCCGCCGGCA
     251  CGGAACGTAN  CGTCATCAA  GCCAGCGGCA  TGAGCACCAA  AAAGCTGCTG
     301  TTGATTCTGT  CGCAGTTCGG  TTTTATTTTT  GCTATTGCCA  CCGTCGCGCT
     351  CGGCGAATGG  GTTGCGCCCA  CACTGAGCCA  AAAAGCCGAA  AACATCAAAG
     401  CCGCGGCCAT  CAACGGCAAA  ATCAGTACCG  GCAATACCGG  CCTTTGGCTG
     451  AAAGAAAAAA  ACAGCATTAT  CAATGTGCGC  GAAATGTTGC  CCGACCATAC
     501  CCTGCTGGGC  ATTAATAATCT  GGGCCCGCAA  CGATAAAAC  GAACTGGCAG
     551  AGGCAGTGA  AGCCGATTCC  GCCGTTTGA  ACAGCGACGG  CAGTTGGCAG
     601  TTGAAAAACA  TCCGCCGCG  CACGCTTGGC  GAAGACAAAG  TCGAGGTCTC
     651  TATTGCGGCT  GAAGAAAANT  GGCCGATTTC  CGTCAAACGC  AACCTGATGG
     701  ACGTATTGCT  CGTCAAACCC  GACCAAATGT  CCGTCGGCGA  ACTGACCACC
     751  TACATCCGCC  ACCTCCAAAN  NNACAGCCAA  AACACCCGAA  TCTACGCCAT
     801  CGCATGGTGG  CGCAAATTGG  TTTACCCCGC  CGCAGCCTGG  GTGATGGCGC
     851  TCGTCGCCTT  TGCCTTTACC  CCGCAAACCA  CCCGCCACGG  CAATATGGGC
     901  TTAATAANTCT  TCGGCGGCAT  CTGCTCGGA  TTGCTGTTCC  ACCTTGCCGG
     951  NCGGCTCTTC  NGGTTTACCA  GCCAACTCTA  CGGCATCCCG  CCCTTCCTCG
    1001  NCGGCGCACT  ACCTACCATA  GCCTTCGCCT  TGCTCGCCGT  TTGGCTGATA
    1051  CGCAAACAGG  AAAACGCTA  A

```

This encodes a protein having amino acid sequence <SEQ ID 56>:

```

      1  MNLISRYIIR QMAVMVAYAL LAFLALYSFF EILYETGNLG KGSYGIWEMX
     51  GYTALKMXAR AYELMPLAVL IGGLVSXSQ L AAGSELXVIK ASGMSTKKLL
    101  LILSQFGFIF AIATVALGEW VAPTLSQKAE NIKAAAINGK ISTGNTGLWL
    151  KEKNSIINVR EMLPDHTLLG IKIWARNDKN ELAEAVEADS AVLNSDGSWQ
    201  LKNIRRLSTLG EDKVEVSIAA EEXWPISVKR NLMDVLLVKP DQMSVGELETT
    251  YIRHLQXXSQ NTRIYAIAWW RKLVPAAAW VMALVAFAPT PQTRRHGNMG
    301  LKXFGGICLG LLFHLAARLF XFTSOLYGIP PFLXGALPTI AFALLAVWLI
    351  RKQEKR*

```

ORF112a and ORF112-1 show 96.3% identity in 326 aa overlap:

```

45  orfl12a.pep  MNLISRYIIRQMAVMVAYALLAFLALYSFFEILYETGNLGKGSYGIWEMXGYTALKMXAR
      |||
orfl12-1       MNLISRYIIRQMAVMVAYALLAFLALYSFFEILYETGNLGKGSYGIWEMLGYTALKMPAR
      |||

50  orfl12a.pep  AYELMPLAVLIGGLVSXSQLAAGSELXVIKASGMSTKKLLLILSQFGFIFAIATVALGEW
      |||
orfl12-1       AYELIPLAVLIGGLVSLSQLAAGSELTVIKASGMSTKKLLLILSQFGFIFAIATVALGEW
      |||

55  orfl12a.pep  ELAEAVEADSAVLNSDGSWQLKNIRRLSTLGEDKVEVSIAAEEXWPISVKNRLMDVLLVKP
      |||
orfl12-1       ELAEAVEADSAVLNSDGSWQLKNIRRLSTLGEDKVEVSIAAENWPISVKNRLMDVLLVKP
      |||

60  orfl12a.pep  DQMSVGELETTYIRHLQXXSQNTRIYAIAWWRKLVPAAAWVMALVAFAPT PQTRRHGNMG
      |||
orfl12-1       DQMSVGELETTYIRHLQNNQNTRIYAIAWWRKLVPAAAWVMALVAFAPT PQTRRHGNMG
      |||

orfl12a.pep  LKXFGGICLGLLFLHLAGRLFXFTSOLYGIPFLXGALPTIAFALLAVWLIRKQEKRX
      || |||| |||| |||| ||||

```


orf112-1

LKLFGGICXGLLFHLAGRLFGFTSQL

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

5 Example 13

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 57>

```

1  ..GCAGTAGCCG AAACCTGCCAA CAGCCAGGGC AAAGGTAAAC AGGCAGGCAG
51  TTCGGTTTCT GTTTCACCTGA AAACCTTCAGG CGACCTTTGC GGCAAACTCA
101 AAACCACCCT TAAAACTTTG GTCTGCTCTT TGGTTTCCCT GAGTATGGTA
151 TTGCCTGCCC ATGCCCAAAT TACCACCGAC AAATCAGCAC CTAAAAACCA
201 GCAGGTCGTT ATCCTTAAAA CCAACACTGG TGCCCCCTTG GTGAATATCC
251 AAACCTCCGAA TGGACGCGGA TTGAGCCACA ACCGCTA.TA CGCATTGTGAT
301 GTTGACAACA AAGGGGCGAG GTTAAACAAC GACCGTAACA ATAATCCGTT
351 TGTGGTCAAA GGCAGTGCGC AATTGATTTT GAACGAGGTA CGCGGTACGG
15 401 CTAGCAAACCT CAACGGCATC GTTACCGTAG GCGGTCAAAA GGCCGACGTG
451 ATTATTGCCA ACCCCAACGG CATTACCGTT AATGGCGGCG GCTTTAAAAA
501 TGTGGTCCGG GGCATCTTAA CTACCGGTGC GCCCAAATC GGCAAAGACG
551 GTGCACTGAC AGGATTTGAT GTGGGTCAAG GCACATTGgA CCGTAGrAGC
601 AGCAGGTTGG AATGATAAAG GCGGAGCmrm yTACACCGGG GTACTTGCTC
20 651 GTGCAGTTGC TTTGCAGGGG AAATTwmrmGG GTAAA.AACT GCGGTTTCT
701 ACCGGTCCTC AGAAAGTAGA TTACGCCAGC GCGGAAATCA GTGCAGGTAC
751 GGCAGCGGGT ACGAAACCGA CTATTGCCCT TGATACTGCC GCACTGGGCG
801 GTATGTACGC CGACAGCATC ACCTGATTG CCAATGAAAA AGGCGTAGGC
851 GTCTAA

```

25 This corresponds to the amino acid sequence <SEQ ID 58; ORF114>:

```

1  ..AVAETANSQG KGKQAGSSVS VSLKTSGLDLC GKLLTTLKTL VCSLVSLSMV
51  LPAHAQITTD KSAPKNQQVV ILKNTNGAEL VNIQTPNGRG LSHNRXYAFD
101 VDNKGAVLNN DRNNPFVVK GSAQLILNEV RGTASKLNGI VTVGGQKADV
151 IIANFNGITV NGGGFKNVGR GILTTGAPQI GKDGALTGFD VVKAHWTVXA
30 201 AGWNDKGGAX YTGVLARAVA LQKXXGKXL AVSTGPQKVD YASGEISAGT
251 AAGTKPTIAL DTAALGGMYA DSITLIANEK GVGv*

```

Further work revealed the complete nucleotide sequence <SEQ ID 59>:

```

1  ATGAATAAAG GTTACATCG CATTATCTTT AGTAAAAAGC ACAGCACCAT
35 51  GGTTCAGTA GCCGAAACTG CCAACAGCCA GGGCAAAGGT AAACAGGCAG
101 GCAGTTCGGT TTCTGTTTCA CTGAAAACCT CAGGCGACCT TTGCGGCAAA
151 CTCAAAACCA CCCTTAAAAC TTTGGTCTGC TCTTTGGTTT CCCTGAGTAT
201 GGTATTGCCT GCCCATGCCC AAATTACCAC CGACAAATCA GCACCTAAAA
251 ACCAGCAGGT CGTTATCCTT AAAACCAACA CTGGTGCCCC CTTGGTGAAT
40 301 ATCCAAACTC CGAATGGACG CGGATTGAGC CACAACCGCT ATACGCAGTT
351 TGATGTTGAC AACAAAGGGG CAGTGTAAAC CAACGACCGT AACAATAATC
401 CGTTTGTGGT CAAAGGCGAG GCGCAATTGA TTTTGAACGA GGTACGCGGT
451 ACGGCTAGCA AACTCAACGG CATCGTTACC GTAGGCGGTC AAAAGGCCGA
501 CGTGATTATT GCCAACCCCA ACGGCATTAC CGTTAATGGC GCGGCTTTA
551 AAAATGTCCG TCGGGGCATC TTAACACCG GTGCGCCCCA AATCGGCAAA
45 601 GACGGTGCAC TGACAGGATT TGATGTGCGT CAAGGCACAT TGACCGTAGG
651 AGCAGCAGGT TGGAATGATA AAGGCGGAGC CGACTACACC GGGGTACTTG
701 CTCGTGCAGT TGCTTTGCAG GGGAAATTAC AGGGTAAAAA CCTGGCGGTT
751 TCTACCGGTC CTCAGAAAGT AGATTACGCC AGCGGCGAAA TCAGTGCAGG
801 TACGGCAGCG GGTACGAAAC CGACTATTGC CTTGATACT GCCGCACTGG
50 851 GCGGTATGTA CGCCGACAGC ATCACACTGA TTGCCAATGA AAAAGGCGTA
901 GGCCTCAAAA ATGCCGGCAC ACTCGAAGCG GCCAAGCAAT TGATTGTGAC
951 TTCGTCAGGC CGCATTGAAA ACAGCGGCGG CATCGCCACC ACTGCCGACG
1001 GCACCGAAGC TTCACCGACT TATCTCTCCA TCGAAACCAC CGAAAAAGGA
1051 GCGGCAGGCA CATTATCTC CAATGGTGGT CGGATCGAGA GCAAAGGCTT
55 1101 ATTGGTTATT GAGACGGGAG AAGATATCAG CTTGCGTAAC GGAGCCGTGG
1151 TGCAGAATAA CGGCAGTCGC CCAGCTACCA CGGTATTAAA TGCTGGTCAT
1201 AATTGGTGA TTGAGAGCAA AACTAATGTG AACAAATGCCA AAGGCCCGGC

```

	1251	TACTCTGTCG	GCCGACGGCC	GTACCGTCAT	CAAGGAGGCC	AGTATTCAGA
	1301	CTGGCACTAC	CGTATACAGT	TCCAGCAAAG	GCAACGCCGA	ATTAGGCAAT
	1351	AACACACGCA	TTACCGGGGC	AGATGTTACC	GTATTATCCA	ACGGCACCAT
5	1401	CAGCAGTTC	GCCGTAATAG	ATGCCAAAGA	CACCGCACAC	ATCGAAGCAG
	1451	GCAAACCGCT	TTCTTTGGAA	GCTTCAACAG	TTACCTCCGA	TATCCGCTTA
	1501	AACGGAGGCA	GTATCAAGGG	CGGCAAGCAG	CTTGCTTTAC	TGGCAGACGA
	1551	TAACTATTCT	GCCAAACTA	CCAATCTGAA	TACTCCCGGC	AATCTGTATG
	1601	TTCATACAGG	TAAAGATCTG	AATTTGAATG	TTGATAAAGA	TTTGTCTGCC
10	1651	GCCAGCATCC	ATTTGAAATC	GGATAACGCT	GCCCATATTA	CCGGCACCAG
	1701	TAAAACCCCT	ACTGCCTCAA	AAGACATGGG	TGTGGAGGCA	GGCTCGCTGA
	1751	ATGTTACCAA	TACCAATCTG	CGTACCAACT	CGGGTAATCT	GCACATTTCAG
	1801	GCAGCCAAAG	GCAATATTCA	GCTTCGCAAT	ACCAAGCTGA	ACGCAGCCAA
	1851	GGCTCTCGAA	ACCACCGCAT	TGCAGGGCAA	TATCGTTTCA	GACGGCCTTC
15	1901	ATGCTGTTTC	TGCAGACGGT	CATGTATCCT	TATTGGCCAA	CGGTAATGCC
	1951	GACTTTACCG	GTCACAATAC	CCTGACAGCC	AAGGCCGATG	TCAATGCAGG
	2001	ATCGGTTGGT	AAAGGCCGTC	TGAAAGCAGA	CAATACCAAT	ATCACTTCAT
	2051	CTTCAGGAGA	TATTACGTTG	GTTGCCGGCA	ACGGTATTCA	GCTTGGTGAC
20	2101	GGAAAACAAC	GCAATTCAAT	CAACGGAAAA	CACATCAGCA	TCAAAAACAA
	2151	CGGTGGTAAT	GCCGACTTAA	AAAACCTTAA	CGTCCATGCC	AAAAGCGGGG
	2201	CATTGAACAT	TCATTCCGAC	CGGGCATTGA	GCATAGAAAA	TACCAAGCTG
	2251	GAGTCTACCC	ATAATACGCA	TCTTAATGCA	CAACACGAGC	GGGTAACGCT
	2301	CAACCAAGTA	GATGCCCTACG	CACACCGTCA	TCTAAGCATT	ACCGGCAGCC
	2351	AGATTGGGCA	AAACGACAAA	CTGCCTTCTG	CCAAACAAGCT	GGTGGCTAAC
25	2401	GGTGTATTGG	CACCTCAATGC	GCGCTATTCC	CAAATTGCGG	ACAACACCCAC
	2451	GCTGAGAGCG	GGTGCAATCA	ACCTTACTGC	CGGTACCGCC	CTAGTCAAGC
	2501	GCGGCAACAT	CAATTGGAGT	ACCGTTTCGA	CCAAAACTTT	GGAAGATAAT
	2551	GCCGAATTAA	AACCATTTGG	CGGACGGCTG	AATATTGAAG	CAGGTAGCCG
30	2601	CACATTAACC	ATCGAACCTG	CCAACCGCAT	CAGTGCGCAT	ACCGACCTGA
	2651	GCATCAAAAC	AGGCGGAAAA	TTGCTGTTGT	CTGCAAAAGG	AGGAAATGCA
	2701	GGTGCGCCTA	GTGCTCAAGT	TTCTCTCATG	GAAGCAAAAG	GCAATATCCG
	2751	TCTGGTTACA	GGAGAAACAG	ATTTAAGAGG	TTCTAAAATT	ACAGCCGGTA
	2801	AAAACTTGGT	TGTCGCCACC	ACCAAAGGCA	AGTTGAATAT	CGAAGCCGTA
	2851	AACAACCTCAT	TCAGCAATTA	TTTTCTCTACA	CAAAAAGCGG	CTGAACCTCAA
35	2901	CCAAAAATCC	AAAGAAATTG	AACAGCAGAT	TGCGCAGTTG	AAAAAAAGCT
	2951	CGCCTAAAAG	CAAGCTGATT	CCAACCTGCG	AAGAAGAACG	CGACCGTCTC
	3001	GCTTTCTATA	TTCAAGCCAT	CAACAAGGAA	GTTAAAGGTA	AAAAACCCAA
	3051	AGGCAAAAGAA	TACCTGCAAG	CCAAGCTTTC	TGCACAAAAT	ATTGACTTGA
	3101	TTTCCGCACA	AGGCATCGAA	ATCAGCGGTT	CCGATATTAC	CGCTTCCAAA
40	3151	AAACTGAACC	TTACGCGCCG	AGGCGTATTG	CCAAAGGCAG	CAGATTACAGA
	3201	GGCGGCTGCT	ATTCTGATTG	ACGGCATAAC	CGACCAATAT	GAAATTGGCA
	3251	AGCCCACCTA	CAAGAGTCAC	TACGACAAAG	CTGCTCTGAA	CAAGCCTTCA
	3301	CGTTTGACCG	GACGTACAGG	GGTAAGTATT	CATGCAGCTG	CGGCACCTCGA
	3351	TGATGCACGT	ATTATTATCG	GTGCATCCGA	AATCAAAAGT	CCCTCAGGCA
45	3401	GCATAGACAT	CAAAGCCCAT	AGTGATATTG	TACTGGAGGC	TGGACAAAAC
	3451	GATGCCCTATA	CCTTCTTAAA	AACCAAAGGT	AAAAGCGGCA	AAATCATCAG
	3501	AAAAACCAAG	TTTACCAGCA	CCCGCGACCA	CCTGATTATG	CCAGCCCCCG
	3551	TCGAGCTGAC	CGCCAACGGC	ATAACGCTTC	AGGCAGGCGG	CAACATCGAA
	3601	GCTAATACCA	CCCGCTTCAA	TGCCCTTGCA	GGTAAAGTTA	CCCTGGTTGC
50	3651	GGGTGAAGAG	CTGCAACTGC	TGGCAGAAGA	AGGCATCCAC	AAGCAGAGT
	3701	TGGATGTCCA	AAAAGCCGCG	CGCTTTATCG	GCATCAAGGT	AGGCAAGAGC
	3751	AATTACAGTA	AAAACGAACT	GAACGAAACC	AAATTGCCTG	TCCGCGTCGT
	3801	CGCCCAAACT	GCAGCCACCC	GTTCAGGCTG	GGATACCGTG	CTCGAAGGTA
	3851	CCGAATTCAA	AACCACGCTG	GCCGGTGCGG	ACATTACAGC	AGGTGTAGGC
55	3901	GAAAAAGCCC	GTGCCGATGC	GAAAATTATC	CTCAAAGGCA	TTGTGAACCG
	3951	TATCCAGTCG	GAAGAAAAAT	TAGAAACCAA	CTCAACCGTA	TGGCAGAAAC
	4001	AGGCCGGACG	CGGCAGCACT	ATCGAAACGC	TGAAACTGCC	CAGCTTCGAA
	4051	AGCCCTACTC	CGCCCAAACT	GACCGCCCCC	GGTGGCTATA	TCGTCGACAT
	4101	TCCGAAAGGC	AATTTGAAAA	CCGAAATCGA	AAAGCTGGCC	AAACAGCCCCG
60	4151	AGTATGCCTA	TCTGAAACAG	CTCCAAGTAG	CGAAAAACGT	CAACTGGAAC
	4201	CAGGTGCAAC	TGGCTTACGA	TAAATGGGAC	TATAAGCAGG	AAGGCTTAAC
	4251	CAGAGCCGGT	GCAGCGATTG	TTACCATAAT	CGTAACCGCA	CTGACTTATG
	4301	GATACGGCGC	AACCGCAGCG	GGCGGTGTAG	CCGCTTCAGG	AAGTAGTACA
	4351	GCCGCGAGTG	CCGGAACAGC	CGCCACAACG	ACAGCAGCAG	CTACTACCGT
65	4401	TTCTACAGCG	ACTGCCATGC	AAACCGCTGC	TTTAGCCTCC	TTGTATAGCC
	4451	AAGCAGCTGT	ATCCATCATC	AATAATAAAG	GTGATGTCGG	CAAAGCGTTG
	4501	AAAGATCTCG	GCACCAAGTGA	TACCGTCAAG	CAGATTGTCA	CTTCTGCCCT
	4551	GACGGCGGGT	GCATTAAATC	AGATGGGCGC	AGATATTGCC	CAATTGAACA
	4601	GCAAGGTAAG	AACCGAACTG	TTCAGCAGTA	CGGGCAATCA	AACTATTGCC
	4651	AACCTTGGAG	GCAGACTGGC	TACCAATCTC	AGTAATGCAG	GTATCTCAGC
70	4701	TGGTATCAAT	ACCGCCGTC	ACGGCGGCAG	CCTGAAAGAC	AACTTAGGCA
	4751	ATGCCGCAT	AGGAGCATTG	GTTAATAGCT	TCCAAGGAGA	AGCCGCCAGC
	4801	AAAATCAAAA	CAACCTTCAG	CGACGATTAT	GTTGCCAAAC	AGTTCCGCCA

5 4851 CGCTTTGGCT GGGTGTGTTA GCGGATTGGT ACAAGGAAAA TGTAAGACG
 4901 GGGCAATTGG CGCAGCAGTT GGGGAAATCG TAGCCGACTC CATGCTTGGC
 4951 GGCAGAAACC CTGCTACACT CAGCGATGCG GAAAAGCATA AGGTTATCAG
 5001 TTACTCGAAG ATTATTGCGG GCAGCGTGGC GGCACTCAAC GGCGGCGATG
 5051 TGAATACTGC GGCGAATGCG GCTGAGGTGG CGGTAGTGAA TAATGCTTTG
 5101 AATTTTGACA GTACCCCTAC CAATGCGAAA AAGCATCAAC CGCAGAGGCC
 5151 CGACAAAACC GCACTGGAAA AAATTATCCA AGGTATTATG CCTGCACATG
 5201 CAGCAGGTGC GATGACTAAT CCGCAGGATA AGGATGCTGC CATTGGGATA
 10 5251 AGCAATATCC GTAATGGCAT CACAGGCCCG ATTGTGATTA CCAGCTATGG
 5301 GGTATTATGCT GCAGGTTGGA CAGCTCCGCT GATCGGTACA GCGGGTAAAT
 5351 TAGCTATCAG CACCTGCATG GCTAATCCTT CTGGTTGTAC TGTCATGGTC
 5401 ACTCAGGCTG CCGAAGCGGG CGCGGGAATC GCCACGGGTG CGGTAACGGT
 5451 AGGCAACGCT TGGGAAGCGC CTGTGGGGGC GTTGTGCGAA GCGAAGCGCG
 5501 CCAAGCAGGC TATACCAACC CAGACAGTTA AAGAAGTTGA TGGCTTACTA
 15 5551 CAAGAATCAA AAAATATAGG TGCTGTAAAT ACACGAATTA ATATAGCGAA
 5601 TAGTACTACT CGATATACAC CAATGAGACA AACGGGACAA CCGGTATCTG
 5651 CTGGCTTTGA GCATGTTCTT GAGGGGCACT TCCATAGGCC TATTGCGAAT
 5701 AACCGTTCAG TTTTACCAT CTCCCAAT GAATTGAAGG TTATACTTCA
 5751 AAGTAATAAA GTAGTTTCTT CTCCGTATC GATGACTCCT GATGGCCAAT
 20 5801 ATATGCGGAC TGTCGATGTA GGAAAAGTTA TTGGTACTAC TTCTATTAAA
 5851 GAAGGTGGAC AACCACAAC TACAATTAAA GTATTACAG ATAAGTCAGG
 5901 AAATTTGATT ACTACATACC CAGTAAAGG AACTAA

This corresponds to the amino acid sequence <SEQ ID 60; ORF114-1>:

25 1 MNKGLHRIIF SKKHSTMVAV AETANSQKGK KOAGSSSVSVS LKTSGLDCGK
 51 LKTTLKLTVL SLVSLSMVLP AHAQITTDKS APKNQOVVIL KNTNGAPLVN
 101 IQTPNGRGLS HNRYTQFDVD NKGAVLNDR NNNPFVVKGS AOLILNEVRG
 151 TASKLNGIVT VGGQKADVII ANPNGITVNG GGFKNVGRGI LTTGAPQIGK
 201 DGALTGFVDR QGTLTGGAAG WNDKGGADYT GVLARAVALQ GKLGQKNLAV
 251 STGPQKVQDYA SGEISAGTAA GTKPTIALDT AALGGMYSADS ITLIANEKGV
 30 301 GVKNAGTLEA AKQLIVTSSG RIENSGRIAT TADGTEASPT YLSIETKEG
 351 AAGTFISNGG RIESKGLLVI ETGEDISLRN GAVVQNGNSR PATTVLNAGH
 401 NLVIESKTNV NNAKGPATLS ADGRTVIKEA SIQTGTTVYS SSKGNAELGN
 451 NTRITGADVT VLSNGTISSS AVIDAKDTAH IEAGKPLSLE ASTVTSDIRL
 501 NGGSIKGGKQ LALLADDNIT AKTTNLNTPG NLYVHTGKDL NLNVDKDLSA
 35 551 ASIHLSKSDNA AHITGTSKTL TASKDMGVEA GSNLVNTNLT RTNSGNLHIQ
 601 AAKGNIQLRN TKLNAKALE TTALQGNIVS DGLHAVSADG HVSLLANGNA
 651 DFTGHNTLTA KADVNAGSVG KGRLLKADNTN ITSSSGDITL VAGNGTQLGD
 701 GKQRNSINGK HISIKNNGGN ADLKNLNVHA KSGALNIHSD RALSIENTKL
 751 ESTHNTLHNA QHERVTNLNV DAYAHRHLSI TGSQIWQNDK LPSANKLVAN
 40 801 GVLALNARYS QIADNTTLIA GAINLTAGTA LVKRGNIWS TVSTKTLVDN
 851 AELKPLAGRL NIEAGSGTTL IEPANRISAH TDLSIKTGGK LLLSAKGGNA
 901 GAPSAQVSSL EAKGNIRLVT GETDLRGSKI TAGKNLVVAT TKGKLNIEAV
 951 NNSFSNYFPT QKAAELNQKS KELEQQIAQL KKSSPKSKLI PTLQEERDRL
 1001 AFYIQAINKE VKGKKPKGKE YLQAKLSAQN IDLISAQGIE ISGSDITASK
 45 1051 KLNLAAGVVL PKAADSEAAA ILIDGITDQY EIGKPTYKSH YDKAALNKPS
 1101 RLTGRTGVSI HAAAALDDAR IIIGASEIKA PSGSIDIKAH SDIVLEAGQN
 1151 DAYTFLKTKG KSGKIIIRTK FTSTRDHLIM PAPVELTANG ITLQAGGNIE
 1201 ANTTREFNAPA GKVTLVAGEE LQLLAEEGIH KHELDVQKSR RFIGIKVGS
 1251 NYSKNEINET KLPVRVVAQT AATRSWDTV LEGTEFKTTL AGADIQAGVG
 50 1301 EKARADAKII LKGIVNRIQS EEKLETNSTV WQKQAGRGST IETLKLPSFE
 1351 SPTPPKLTAP GGYIVDIPKG NLKTEIEKLA KOPEYAYLKQ LQVAKNVNWN
 1401 QVQLAYDKWD YKQEGLTRAG AAIVTIIVTA LTYGYGATAA GGVAAGSSST
 1451 AAAAGTAATT TAAATTVSTA TAMQTAALAS LYSQAASVSI NNKGDVKGAL
 55 1501 KDLGTSDTVK QIVTSALTAG ALNQMGADIA QLNSKVTEL FSSTGNQTIA
 1551 NLGGRLATNL SNAGISAGIN TAVNGGSLKD NLGNAALGAL VNSFQGEAAS
 1601 KIKTTFSDDY VAKQFAHALA GCVSGLVQVK CKDGAIGAAV GEIVADSMGL
 1651 GRNPATLSDA EKHKVISYSK IAGSVAALN GGDVNTAANA AEVAVVNNAL
 1701 NFDSTPTNAK KHQPKPKDKT ALEKIIQGIM PAHAAGAMTN PQDKDAIWI
 1751 SNIRNGITGP IVITSYGVYA AGWTAPLIGT AGKLAISTCM ANPSGCTVMV
 60 1801 TQAAEAGAGI ATGAVTVGNA WEAPVGALSK AKAAKQAIP TQVKELDGLL
 1851 QESKNIGAVN TRINIANSTT RYTPMRQTGQ PVSAGFEHVL EGHFHRPIAN
 1901 NRSVFTISPN ELKVILQSNK VVSSPVSMTF DGQYMRTVDV GKVIIGTTSIK
 1951 EGGQPTTTIK VFTDKSGNLI TYPVKGN*

Computer analysis of this amino acid sequence predicts a transmembrane region and also gives the

65 following results:

Homology with a predicted ORF from *N.meningitidis* (strain A)

ORF114 shows 91.9% identity over a 284aa overlap with an ORF (ORF114a) from strain A of *N. meningitidis*:

5	orf114.pep	AVAETANSQGGKQAGSSVSVSLKTSGLDLCGKLTTLKTLVC	10	20	30	40
	orf114a	MNKGHLHRIIFS KKHSTMVAVAETANSQGGKQAGSSVSVSLKTSGLDLCGKLTTLKTLVC	10	20	30	40
10	orf114.pep	SLVSLSMVLPAAHQITTDKSAFKNQVVLKTNLTGAPLVNIQTPNRGLSHNRXYAFDVD	50	60	70	80
	orf114a	SLVSLSMXXXXXXQITTDKSAFKNQVVLKTNLTGAPLVNIQTPNRGLSHNRXYQFDVD	50	60	70	80
15	orf114.pep	NKGAVLNDRNNNPFVVGSAQLILNEVRGTASKLNGIVTVGGQKADVIIANPNGITVNG	110	120	130	140
	orf114a	NKGAVLNDRNNNPFVVGSAQLILNEVRGTASKLNGIVTVGGQKADVIIANPNGITVNG	110	120	130	140
20	orf114.pep	GGFKNVGRGILTTGAPQIGKDGALTGFDDVKAHWTVXAAGWNDKGGAXYTGVLARAVALQ	170	180	190	200
	orf114a	GGFKNVGRGILTTGAPQIGKDGALTGFDDVKAHWTVXAAGWNDKGGAXYTGVLARAVALQ	170	180	190	200
25	orf114.pep	GKXXGKXLAVSTGPQKVDYASGEISAGTAAGTKPTIALDTAALGGMYADSITLIANEKGV	230	240	250	260
	orf114a	GKLGKKNLAVSTGPQKVDYASGEISAGTAAGTKPTIALDTAALGGMYADSITLIAXEKG	230	240	250	260
30	orf114.pep	GVX	250	260	270	280
	orf114a	GVKNAGTLEAAKQLIVTSSGRIENSGRIATTADGTEASPTYLXIETTEKGAXGTGISNGG	250	260	270	280
35	orf114.pep		310	320	330	340
	orf114a		310	320	330	340

The complete length ORF114a nucleotide sequence <SEQ ID 61> is:

40	1	ATGAATAAAG	GTTTACATCG	CATTATCTTT	AGTAAAAAGC	ACAGCACCAT
	51	GGTTGCAGTA	GCCGAAATCG	CCAACAGCCA	GGGCAAAGGT	AAACAGGCAG
	101	GCAGTTCGGT	TTCTGTTTCA	CTGAAAACCT	CAGGCGACCT	TTGCGGCAAA
	151	CTCAAAACCA	CCCTTAAAC	CTTGGTCTGC	TCTTTGGTTT	CCCTGAGTAT
	201	GGNATTNCNN	NNCNTNCCC	AAATTACCAC	CGACAAATCA	GCACCTAAAA
45	251	ACCANCAGGT	CGTTATCCTT	AAAACCAACA	CTGGTGCCCC	CTTGGTGAAT
	301	ATCCAAATC	CGAATGGACG	CGGATTGAGC	CACAACCGCT	ATACGCAGTT
	351	TGATGTTGAC	AACAAAGGGG	CAGTGTTAAA	CAACGACCGT	AACAATAATC
	401	CGTTTCTGGT	CAAAGGCAGT	GCGCAATTGA	TTTGAACGA	GGTACGCGGT
	451	ACGGCTAGCA	AACTCAACGG	CATCGTTACC	GTAGGCGGTC	AAAAGGCCGA
50	501	CGTGATTATT	GCCAAACCCA	ACGGCATTAC	CGTTAATGGC	GGCGGCTTTA
	551	AAAATGTCGG	TCGGGGCATC	TTAACTATCG	GTGCGCCCCA	AATCGGCAAA
	601	GACGGTGCAC	TGACAGGATT	TGATGTGCGT	CAAGGCACAT	TGACCGTAGG
	651	AGCAGCAGGT	TGGAATGATA	AAGGCGGAGC	CGACTACACC	GGGGTACTTG
	701	CTCGTGCAGT	TGCTTTGCAG	GGGAAATTAC	AGGGTAAAAA	CCTGGCGGTT
55	751	TCTACCGGTC	CTCAGAAAGT	AGATTACGCC	AGCGGCGAAA	TCAGTGCAGG
	801	TACGGCAGCG	GGTACGAAAC	CGACTATTGC	CCTTGATACT	GCCGCATCTG
	851	GCGGTATGTA	CGCCGACAGC	ATCACACTGA	TTGCCANTGA	AAAAGGCGTA
	901	GGCGTCAAAA	ATGCCGGCAC	ACTCGAAGCG	GCCAAGCAAT	TGATTGTGAC
	951	TTCTGTCAGG	CGCATTGAAA	ACAGCGGCCG	CATCGCCACC	ACTGCCGACG
60	1001	GCACCGAAGC	TTACCCGACT	TATCTNNCNA	TCGAAACCAC	CGAAAAAGGA
	1051	GCNNCAGGCA	CATTTATCTC	CAATGGTGGT	CGGATCGAGA	GCAAAGGCTT
	1101	ATTGTTTATT	GAGACGGGAG	AAGATATCAN	CTTGCCTAAC	GGAGCCGTTG
	1151	TGCAGAATAA	CGGCAGTCGC	CCAGCTACCA	CGGTATTAAA	TGCTGGTCAT
	1201	AATTTGGTGA	TTGAGAGTAA	AACTAATGTG	AACAATGCCA	AAGGCTCGNC

1251 TAATCTGTCG GCCGGCGGTC GTACTACGAT CAATGATGCT ACTATTCAAG
 1301 CGGGCAGTTC CGTGTACAGC TCCACCAAAG GCGATACTGA NTTGGGTGAA
 1351 AATACCCGTA TTATTGCTGA AAACGTAAAC GTATTATCTA ACGGTAGTAT
 1401 TGGCAGTGCT GCTGTAATTG AGGCTAAAGA CACTGCACAC ATTGAATCGG
 5 1451 GCAAACCGCT TTCTTTAGAA ACCTCGACCG TTGCCTCAA CATCCGTTTG
 1501 AACAAACGTA ACATTAAAGG CGGAAAGCAG CTTGCTTTAC TGGCAGACGA
 1551 TAACATTACT GCCAAACTA CCAATCTGAA TACTCCCGGC AATCTGTATG
 1601 TTCATACAGG TAAAGATCTG AATTTGAATG TTGATAAAGA TTTGTCTGCC
 1651 GCCAGCATCC ATTTGAAATC GGATAACGCT GCCCATATTA CCGGCACCAG
 10 1701 TAAAACCTC ACTGCCTCAA AAGACATGGG TGTGGAGGCA GGCTTGCTGA
 1751 ATGTTACCAA TACCAATCTG CGTACCAACT CGGGTAATCT GCACATTGAG
 1801 GCAGCCAAAG GCAATATTCA GCTTCGCAAT ACCAAGCTGA ACGCAGCCAA
 1851 GGCTCTCGAA ACCACCGCAT TGCAGGGCAA TATCGTTTCA GACGGCCTTC
 1901 ATGCTGTTC TGCAGACGGT CATGTATCCT TATTGGCCAA CGGTAAATGCC
 15 1951 GACTTTACCG GTCACAATAC CCTGACAGCC AAGGCCGATG TCNATGCAGG
 2001 ATCGGTTGGT AAAGGCGGTC TGAAAGCAGA CAATACCAAT ATCACTTCAT
 2051 CTTCAGGAGA TATTACGTTG GTTGCCGNNN NCGGTATTCA GCTTGGTGAC
 2101 GGAAACAAC GCAATTCAT CAACGGAAAA CACATCAGCA TCAAAAAACA
 2151 CGGTGGTAAT GCCGACTTAA AAAACCTTAA CGTCCATGCC AAAAGCGGGG
 20 2201 CATTGAACAT TCATTCCGAC CGGGCATTGA GCATAGAAAA TACNAAGCTG
 2251 GAGTCTACCC ATAATACGCA TCTTAATGCA CAACACGAGC GGGTAACGCT
 2301 CAACCAAGTA GATGCCTACG CACACCGTCA TCTAAGCATT ANCGGCAGCC
 2351 AGATTTGGCA AAACGCACAA CTGCCTTCTG CCAACAAGCT GGTGGCTAAC
 2401 GGTGTATTGG CANTCAATGC GCGCTATTCC CAAATTGCCG ACAACACCAC
 25 2451 GCTGAGAGCG GGTGCAATCA ACCTTACTGC CGGTACCGCC CTAGTCAAGC
 2501 GCGGCAACAT CAATTGGAGT ACCGTTTCGA CCAAGACTTT GGAAGATAAT
 2551 GCCGAATTAA AACCATTGGC CGGACGGCTG AATATTGAAG CAGGTAGCGG
 2601 CACATTAACC ATCGAACCTG CCAACCGCAT CAGTGCGCAT ACCGACCTGA
 2651 GCATCAAAAC AGGCGGAAAA TTGCTGTTGT CTGCAAAAGG AGGAAATGCA
 30 2701 GGTGCGCNTA GTGCTCAAGT TTCCTCATTG GAAGCAAAAG GCAATATCCG
 2751 TCTGGTTACA GGAGNAACAG ATTTAAGAGG TTCTAAAATT ACAGCCGGTA
 2801 AAAACTTGGT TGTCCGCCACC ACCAAAGGCA AGTTGAATAT CGAAGCCGTA
 2851 AACAACTCAT TCAGCAATTA TTTTCNTACA CAAAAGNGN NNGNNTCAA
 35 2901 CCAAAAATCC AAAGAATTGG AACAGCAGAT TGCGCAGTTG AAAAAAGCT
 2951 CGCNTAAAAG CAAGCTGATT CCAACCTGCG AAGAAGAACG CGACCGTCTC
 3001 GCTTTCTATA TTCAAGCCAT CAACAAGGAA GTTAAAGGTA AAAAAACCAA
 3051 AGGCAAGAA TACCTGCAAG CCAAGCTTTC TGCACAAAAT ATTGACTTGA
 3101 TTTCCGCACA AGGCATCGAA ATCAGCGGTT CCGATATTAC CGCTTCCAAA
 3151 AAAGTGAACC TTCACGCCGC AGGCGTATTG CCAAGGCAG CAGATTTCGA
 40 3201 GCGGCGTGCT ATTCTGATTG ACGGCATAAC CGACCAATAT GAAATGGCA
 3251 AGCCACCTA CAAGAGTCAC TACGACAAAG CTGCTCTGAA CAAGCCTTCA
 3301 CGTTTGACCG GACGTACGGG GGTAAGTATT CATGCAGCTG CGGCACTCGA
 3351 TGATGCACGT ATTATTATCG GTGCATCCGA AATCAAAGCT CCCTCAGGCA
 45 3401 GCATAGACAT CAAAGCCCAT AGTGATATTG TACTGGAGGC TGGACAAAAC
 3451 GATGCCTATA CTTCTTANA AACCAAAGGT AAAAGCGGCA NAATNATCAG
 3501 AAAAAACNAAG TTTACCAGCA CCNGCGANCA CCTGATTATG CCAGCCCCNG
 3551 TCGAGCTGAC CGCCAAACGGT ATCAGCTTTC AGGCAGGCGG CAACATCGAA
 3601 GCTAATACCA CCGCTTCAA TGCCCTGCA GGTAAGTTA CCCTGGTTGC
 50 3651 GGGTGAANAG NTGCAACTGC TGGCAGAAGA AGGCATCCAC AAGCAGGAGT
 3701 TGGATGTCCA AAAAAGCCGC CGCTTTATCG GCATCAAGGT AGGTNAGAGC
 3751 AATTACAGTA AAAACGAACT GAACGAAACC AAATTGCCTG TCCGCGTCTG
 3801 CGCCCAANT GCAGCCACCC GTTCAGGCTG GGATACCGTG CTCGAAGGTA
 3851 CCGAATTCAA AACCACGCTG GCCGGTGCCG ACATTAGGC AGGTGTANGC
 3901 GAAAAAGCCC GTGTCGATGC GAAAATTATC CTCAAAGGCA TTGTGAACCG
 55 3951 TATCCAGTCG GAAGAAAAAT TAGAAACCAA CTCAACCGTA TGGCAGAAAC
 4001 AGGCCGACG CGGCAGCACT ATCGAAACGC TAAACTGCC CAGCTTCGAA
 4051 AGCCCTACTC CGCCCAAAAT GTCCGCACCC GGCGGNTATA TCGTCGACAT
 4101 TCCGAAAGGC AATCTGAAAA CCGAAATCGA AAAGCTGTCC AAACAGCCCG
 4151 AGTATGCCTA TCTGAAACAG CTCCAAGTAG CGAAAAACAT CAACTGGAAT
 60 4201 CAGGTGCAGC TTGCTTACGA CAGATGGGAC TACAAACAGG AGGGCTTAAC
 4251 CGAAGCAGGT GCGGCGATTA TCGCACTGGC CGTTACCGTG GTCACCTCAG
 4301 GCGCAGGAAC CGGAGCGGTA TTGGGATTAA ACGGTGCGNC CGCCGCGCA
 4351 ACCGATGCAG CATTGCGCTC TTTGGCCAGC CAGGCTTCCG TATCGTTCAT
 4401 CAACAACAAA GGCAGTGTG GCAAAACCTT GAAAGAGCTG GGCAGAGCA
 65 4451 GCACGGTGAA AAATCTGGTG GTTGCCGCGG CTACCGCAGG CGTAGCCGAC
 4501 AAAATCGGCG CTTCCGCACT GANCAATGTC AGCGATAAGC AGTGGATCAA
 4551 CAACCTGACC GTCAACCTAG CCAATGNCGG GCAGTGCCGC ACTGAttaa

This encodes a protein having amino acid sequence <SEQ ID 62>:

1 MNKGLHRIIF SKKHSTMVAV AETANSQKGK KQAGSSVSVS LKTSGLCGK

	51	LKTTTLKTLVC	SLVSLSMXXX	XXXQITTDKS	APKNXQVVIL	KTNTGAPLVN
	101	IQTPNGRGLS	HNRYTQFDVD	NKGAVLNDR	NNNPFVLVKS	AQLILNEVRG
	151	TASKLNGIVT	VGGQKADVII	ANPNGITVNG	GGFKNVGRGI	LTIGAPQIGK
5	201	DGALTGFQDVR	QGTTLTVGAAG	WNDKGGADYT	GVLARAVALQ	GKLGKKNLAV
	251	STGPQKVDYA	SGEISAGTAA	GTKPTIALDT	AALGGMYADS	ITLIAXEKGV
	301	GVKNAGTLEA	AKQLIVTSSG	RIENSGRIAT	TADGTEASPT	YLXIETTEKG
	351	AXGTFISNGG	RIESKGLLVI	ETGEDIXLRN	GAVVQNNNGSR	PATTVLNAGH
	401	NLVIESKTNV	NNAKGSXNLS	AGGRTTINDA	TIQAGSSVYS	STKGDXTLGE
10	451	NTRIIAENV	VLSNGSIGSA	AVIEAKDTAH	IESGKPLSLE	TSTVASNIRL
	501	NNGNIKGGKQ	LALLADDNIT	AKTTNLNTPG	NLYVHTGKDL	NLNVDKDLA
	551	ASIHLSKSDNA	AHITGTSKTL	TASKDMGVEA	GLLNVTNTNL	RTNSGNLHIQ
	601	AAKGNQLRN	TKLNAAKALE	TTALQGNIVS	DGLHAVSADG	HVSLLANGNA
	651	DFTGHNTLTA	KADVXAGSVG	KGRLLKADNTN	ITSSSGDITL	VAXXGQLQGD
15	701	GKQRNSINGK	HISIKNNGGN	ADLKNLNVHA	KSGALNIHSD	RALSIENTKL
	751	ESTHNTHLNA	QHERVTLNQV	DAYAHRHLSI	XGSQIWQNDK	LPSANKLVAN
	801	GVLAXNARYS	QIADNTTLRA	GAINLTAGTA	LVKRGNIWS	TVSTKTLEDN
	851	AELKPLAGRL	NIEAGSGTTL	IEPANRISAH	TDLSIKTGGK	LLLSAKGGNA
	901	GAXSAQVSSL	EAKGNIRLVT	GXTDLRGSKI	TAGKNLVVAT	TKGKLNIEAV
20	951	NNSFSNYFXT	QKXXXLNQKS	KELEQQIAQL	KKSSXKSKLI	PTLQEERDRL
	1001	AFYIQAINKE	VKGKPKGKE	YLOAKLSAQN	IDLISAQGIE	ISGSDITASK
	1051	KLNLHAAGVL	PKAADSEAAA	ILIDGITDQY	EIGKPTYKSH	YDKAALNKPS
	1101	RLTGRTGVSI	HAAALDDAR	IIIGASEIKA	PSGSIDIKAH	SDIVLEAGQN
	1151	DAYTFLXTKG	KSGXXIRKTK	FTSTXXHLIM	PAPVELTANG	ITLQAGGNIE
25	1201	ANTTRFNAPA	GKVTLVAGEX	XQLLAEEGIH	KHELDVQKSR	RFIGIKVGSX
	1251	NYSKNELNET	KLPVRVVAQX	AATRSQWDTV	LEGTEFKTTL	AGADIQAGVX
	1301	EKARVDAKII	LKGIVNRIQS	EKLETNSTV	WQKQAGRGST	IETLKLPSFE
	1351	SPTPKLSAP	GGYIVDIPKG	NLKTEIEKLS	KQPEYAYLKQ	LQVAKNINWN
	1401	QVQLAYDRWD	YKQEGLTEAG	AAIILAVTV	VTSGAGTGAV	LGLNGAXAAA
30	1451	TDAAFASLAS	QASVSFINNK	GDVGKTLKEL	GRSSTVKNLV	VAAATAGVAD
	1501	KIGASALXNV	SDKQWINNLT	VNLANXGQCR	TD*	

ORF114-1 and ORF114a show 89.8% identity in 1564 aa overlap

	orf114a.pep	MNKGLHRIIFS	SKKHSTMVAVAETANSQ	GKQAGSSVS	SLKTS	SGDLCGKLT	TLKTLVC
35	orf114-1	MNKGLHRIIFS	SKKHSTMVAVAETANSQ	GKQAGSSVS	SLKTS	SGDLCGKLT	TLKTLVC
	orf114a.pep	SLVSLSMXXXXXX	QITTDKSAPKNXQVVIL	KTNTGAPLVN	IQT	PNGRGLSHNRYT	QFDVD
	orf114-1	SLVSLSMVLPAHA	QITTDKSAPKNQVVIL	KTNTGAPLVN	IQT	PNGRGLSHNRYT	QFDVD
40	orf114a.pep	NKGAVLNDRNN	NNPFLVKS	AQLILNEVRG	TASKLNGIVTV	GGQKADVII	ANPNGITVNG
	orf114-1	NKGAVLNDRNN	NNPFLVKS	AQLILNEVRG	TASKLNGIVTV	GGQKADVII	ANPNGITVNG
45	orf114a.pep	GGFKNVGRGILT	IGAPQIGKDGALT	GFQDVRQGT	TLTVGAAGW	NKGGADYT	GVLARAVALQ
	orf114-1	GGFKNVGRGILT	IGAPQIGKDGALT	GFQDVRQGT	TLTVGAAGW	NKGGADYT	GVLARAVALQ
50	orf114a.pep	GKLGKKNLAV	STGPQKVDYASGEIS	AGTAAGTKPTIALD	TAAALGGMYADS	SITLIA	XEKGV
	orf114-1	GKLGKKNLAV	STGPQKVDYASGEIS	AGTAAGTKPTIALD	TAAALGGMYADS	SITLIA	NEKGV
55	orf114a.pep	GVKNAGTLEAA	QQLIVTSSGRIENSGRIAT	TADGTEASPT	YLXIETTEKG	GAXGTFIS	NGG
	orf114-1	GVKNAGTLEAA	QQLIVTSSGRIENSGRIAT	TADGTEASPT	YLSIETTEKG	GAXGTFIS	NGG
	orf114a.pep	RIESKGLLVI	ETGEDIXLRNGAVVQNNNGSR	PATTVLNAGH	NLVIESKTNV	NNNAKGSXNLS	
	orf114-1	RIESKGLLVI	ETGEDISLRNGAVVQNNNGSR	PATTVLNAGH	NLVIESKTNV	NNNAKGPATLS	
60	orf114a.pep	AGGRTTINDA	TIQAGSSVYSSTKGD	XTLGEN	TRIIAENVTV	VLSNGSIGSA	AVIEAKDTAH
	orf114-1	ADGR	TVIKEASIQGT	TVYSSSKGNAELGNN	TRITGADVTV	LSNGTIS	SSSAVIDAKDTAH
65	orf114a.pep	IESGKPLS	LETSTVASNIRLN	NNGNIKGGKQL	LALLADDNIT	AKTTNLNTPG	NLYVHTGKDL
	orf114-1	IEAGKPLS	EASTVTS	DIRLNGGSIKGGKQL	LALLADDNIT	AKTTNLNTPG	NLYVHTGKDL
	orf114a.pep	NLNVDKDL	SAASIHLSKSDNA	AHITGTSKTL	TASKDMGVEA	GLLNVTNTNL	RTNSGNLHIQ

	orf114-1	NLNVDKDLAASIAHLKSDNAAHITGTSKTLTASKDMGVEAGSLNVTNTNLRTNSGNLHIQ	
	orf114a.pep	AAKGNIQLRNTKLNAAKALETTALQGNIVSDGLHAVSADGHVSLLANGNADFTGHNTLTA	
5	orf114-1	AAKGNIQLRNTKLNAAKALETTALQGNIVSDGLHAVSADGHVSLLANGNADFTGHNTLTA	
	orf114a.pep	KADVXAGSVGKGRKADNTNITSSSGDITLVAXXGIQLGDGKQORSINGKHISIKNNGGN	
10	orf114-1	KADVXAGSVGKGRKADNTNITSSSGDITLVAXXGIQLGDGKQORSINGKHISIKNNGGN	
	orf114a.pep	ADLKNLVHAKSGALNIHSDRALSIENTKLESTHNTHLNAQHERVTLNQVDAYAHRHLSI	
	orf114-1	ADLKNLVHAKSGALNIHSDRALSIENTKLESTHNTHLNAQHERVTLNQVDAYAHRHLSI	
15	orf114a.pep	XGSQIWQNDKLP SANKLVANGVLAXNARYS QIADNTTLRAGAINLTAGTALVKRGNINWS	
	orf114-1	XGSQIWQNDKLP SANKLVANGVLAXNARYS QIADNTTLRAGAINLTAGTALVKRGNINWS	
20	orf114a.pep	TVSTKTLEDNAELKPLAGRLNIEAGSGTLTIEPANRISAHTDLSIKTGGKLLLSAKGGNA	
	orf114-1	TVSTKTLEDNAELKPLAGRLNIEAGSGTLTIEPANRISAHTDLSIKTGGKLLLSAKGGNA	
	orf114a.pep	GAXSAQVSSLEAKGNIRLVGTGDLRGSKITAGKNLVVATTGKGLNIEAVNNSFSNYFXT	
25	orf114-1	GAXSAQVSSLEAKGNIRLVGTGDLRGSKITAGKNLVVATTGKGLNIEAVNNSFSNYFXT	
	orf114a.pep	QKXXXLNQKSKELEQQIAQLKKSSXKSKLIPTLQEERDLAFYIQAINKEVKGKPKGKE	
30	orf114-1	QKAAELNQKSKELEQQIAQLKKSSXKSKLIPTLQEERDLAFYIQAINKEVKGKPKGKE	
	orf114a.pep	YLQAKLSAQNIDLISAQGIEISGSDITASKKLNLAAGVLPKAADSEAAAILIDGITDQY	
	orf114-1	YLQAKLSAQNIDLISAQGIEISGSDITASKKLNLAAGVLPKAADSEAAAILIDGITDQY	
35	orf114a.pep	EIGKPTYKSHYDKAALNKPSRLTGRTGVSIAHAAALDDARIIGASEIKAPSGSIDIKAH	
	orf114-1	EIGKPTYKSHYDKAALNKPSRLTGRTGVSIAHAAALDDARIIGASEIKAPSGSIDIKAH	
40	orf114a.pep	SDIVLEAGQNDAYTFLXTKGKSGXIRKTKFTSTXXHLIMPAPVELTANGITLQAGGNIE	
	orf114-1	SDIVLEAGQNDAYTFLXTKGKSGXIRKTKFTSTRDHLIMPAPVELTANGITLQAGGNIE	
	orf114a.pep	ANTTRFNAPAGKVTLVAGEXXQLLAEEGIHKHELDVQKSRRFIGIKVGXSNYSKNELNET	
45	orf114-1	ANTTRFNAPAGKVTLVAGEELQLLAEEGIHKHELDVQKSRRFIGIKVGXSNYSKNELNET	
	orf114a.pep	KLPVRVVAQXAATRSQWDTVLEGTEFKTTLAGADIQAGVGEKARVDAKIIKLGIVNRIQS	
50	orf114-1	KLPVRVVAQXAATRSQWDTVLEGTEFKTTLAGADIQAGVGEKARVDAKIIKLGIVNRIQS	
	orf114a.pep	EEKLETNSTVWQKQAGRGSTIETLKLPSFESPTPKLSAPGGYIVDIPKGNLKTIEIKLS	
	orf114-1	EEKLETNSTVWQKQAGRGSTIETLKLPSFESPTPKLSAPGGYIVDIPKGNLKTIEIKLS	
55	orf114a.pep	KQPEYAYLKQLQVAKNINWQVQLAYDRWDYKQEGLTEAGAAIIALAVTVVTSGAGTGAV	
	orf114-1	KQPEYAYLKQLQVAKNINWQVQLAYDRWDYKQEGLTEAGAAIIALAVTVVTSGAGTGAV	
60	orf114a.pep	LGLNGA-----XAAATD-----AAFASLASQASVSFINNKGDVGKTL 1477	
	orf114-1	GGVAASGSSTAAAAGTAATTTAAATTVSTATAMQTAALASLYSQAAVSIINNKGDVGKAL 1500	
	orf114a.pep	KELGRSSTVKNLVVAAATAGVADKIGA-----SALXNVSDKQWINNL----TVNL 1523	
65	orf114-1	KDLGTSQVTKQIVTSALTAGALNQMGADIAQLNSKVRTELFSSSTGNQTIANLGGRLATNL 1560	
	orf114a.pep	ANXGQCRDX	
70	orf114-1	SNAGISAGINTAVN...	

Homology with pspA putative secreted protein of *N.meningitidis* (accession number AF030941)

ORF114 and pspA protein show 36% aa identity in 302aa overlap:

```

Orf114: 1  AVAETANSQKGKQAGSSVSLSL-----KTSGDXXXXXXXXXXXXXXXXXXXXXPAHAQ 56
          AVAE + GK Q + SV + S PA A
5  pspA: 19  AVAENVHRDGKSMQDSEASVRVTGAASVSSARAAGFRMAAFSVMLALGVAAFSPAPAS 78

Orf114: 57  -ITTDKSAPKNQOVVILKTNTGAPLVNIQTPNGRGLSHNRXYAFDVKNGAVLNDRNN- 114
          I DKSAPKNQ VIL+T G P VNIQTP+ +G+S NR FDVD KG +LNN R+N
10 pspA: 79  GIIADKSAPKNQQAIVILQTANGLPQVNIQTPSSQGVSVNRFKQFDVDEKGVILNNSRSNT 138

Orf114: 115  -----NPFVVKGSAQLILNEV-RGTASKLNGIVTVGGQKADVIIANPNGITVNGG 163
          NP + +G A++I+N++ S LNG + VGG++A+V++ANP+GI VNGG
15 pspA: 139  QTQLGGWIIQGNPHLARGEARVIVNQIDSSNPSSLNGYIEVGGKRAEVVVANPSGIRVNGG 198

Orf114: 164  GFKNVGRGILTTGAPQIGKDGALTGFDDVKAHWTVXAAGWNDKGGAXYTGVLARAVALLQ 223
          G N LT+G P + +G LTGFDV + G D A YT +L+RA +
20 pspA: 199  GLINAASVTLTSGVPVL-NNGNLTGFDVSSGKVVIGGKGL-DTSDADYTRILSRAAEINA 256

Orf114: 224  KXXGKXLAVSTGPKVDYASGEISAGTAAGTK----PTIALDTAALGGMYADSITLIANE 279
          GK + V +G K+D+ +A + PT+A+DTA LGGMYAD ITLI+ +
25 pspA: 257  GVWGKDVKVVSNGKLNDFDGLAKTASAPSSSDSVTPTVAIDTATLGGMYADKITLISTD 316

Orf114: 280  KG 281
          G
25 pspA: 317  NG 318

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ORF114a is also homologous to pspA:

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gi|2623258 (AF030941) putative secreted protein [Neisseria meningitidis] Length
= 2273
30 Score = 261 bits (659), Expect = 3e-68
   Identities = 203/663 (30%), Positives = 314/663 (46%), Gaps = 76/663 (11%)

Query: 1  MNKGLHRIIFSCKHSTMVAVAETANSQKGKQAGSSVSLSL-----TSGDXXXXXXXXXX 55
          MNK +++IF+KK S M+AVAE + GK Q + SV + +S
35 Sbjct: 1  MNKRCYKVFINKKRSCMMAVAENVHRDGKSMQDSEASVRVTGAASVSSARAAGFRMAA 60

Query: 56  XXXXXXXXXXXXXXXXQITTDKSAPKNQOVVILKTNTGAPLVNIQTPNGRGLSHNRYT 115
          I DKSAPKN Q VIL+T G P VNIQTP+ +G+S NR+
40 Sbjct: 61  FSVMLALGVAAFSPAPASGIIADKSAPKNQQAIVILQTANGLPQVNIQTPSSQGVSVNRFK 120

Query: 116  QFDVDNKGAVLNDRNN-----NPFVVKGSAQLILNEV-RGTASKLNGIVTVGG 163
          QFDVD KG +LNN R+N NP L +G A++I+N++ S LNG + VGG
45 Sbjct: 121  QFDVDEKGVILNNSRSNTQTQLGGWIIQGNPHLARGEARVIVNQIDSSNPSSLNGYIEVGG 180

Query: 164  QKADVIIANPNGITVNGGGGFKNVGRGILTTGAPQIGKDGALTGFDDVROGTLTVGAAGWND 223
          ++A+V++ANP+GI VNGGG N LT G P + +G LTGFDV G + +G G D
50 Sbjct: 181  KRAEVVVANPSGIRVNGGGGLINAASVTLTSGVPVL-NNGNLTGFDVSSGKVVIGGKGL-D 238

Query: 224  KKGADYTGVLARAVALLQKLGKNLAVSTGPKVDYASGEISAGTAAGTK----PTIALD 279
          ADYT +L+RA + + GK++ V +G K+D+ +A + PT+A+D
55 Sbjct: 239  TSDADYTRILSRAAEINAGVWGKDVKVVSNGKLNDFDGLAKTASAPSSSDSVTPTVAID 298

Query: 280  TAALGGMYADSITLIAEKGVGKVNAGTLEAAK-QLIVTSSGRIENSGRIATTADGTEAS 338
          TA LGGMYAD ITLI+ + G ++N G + AA + +++ G++ NSG I +A+
60 Sbjct: 299  TATLGGMYADKITLISTDNGAVIRNKGRIFAATGGVTLSDAGKLSNSGSI-----DAA 351

Query: 339  PTYLXIETTEKGAXGTFISNGGRIESKGLLVITGEDIKLRNGAVVQNNGSRPATTVLNA 398
          + +T + + G I S V++ + I + G + GS + +
65 Sbjct: 352  EITISAQTVD-----NRQGFIRSGKSVLKVSDGINNQAGLI----GSAGLLDIRDT 399

Query: 399  GHNLVIESKTNVNNAKGS----XNLSAGGRTTINDATIAGSSVYSSTKGDXTLXGENTRI 454
          G +S ++NN G+ ++S ++ ND + A V S + D G+
Sbjct: 400  G-----KSSLHINNTDGTIIAGKDVSLQAKSLDNDGILTAARDV-SVSLHDDFAGKRDIE 453

Query: 455  IAENVTVLSNGSIGSAVIEAKDTAHIESGKPLSLETSTVASNIRLNNGNIKGGKQLALL 514
          +T + G + + +I+A DT + + + + + S R G L+

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Sbjct: 454 AGRTLTFSTQGR LKNTRIIQAGDTVSLTAAQIDNTVSGKIQSGNRTGLNGKNGITNRGLI 513
 Query: 515 ADDNIT-----AKTTNLTNTPGNLYVHTGKDLNLNVDKDLASAASIHLSKSDNAAHITGTSKT 569
 + IT AK+ N T G +Y G + + D L+ AA
 Sbjct: 514 NSNGITLLQTEAKSDNAGT-GRIY---GSRVAEADTLLNREETVNGETKAA-----V 562
 Query: 570 LTASKDMGVEAGXXXXXXXXXXXXSGNLHIQAA---KGNIQLRNTKL-NAAKALETALQ 625
 + A + + + A SG+LHI +A +Q NT L N + A+E++
 Sbjct: 563 IAARERLDIGAREIENREAALLSSSGDLHIGSALNGSRQVQGANTSLHNRSAAIESS--- 619
 Query: 626 GNI 628
 GNI
 Sbjct: 620 GNI 622
 Score = 37.5 bits (85), Expect = 0.53
 Identities = 87/432 (20%), Positives = 159/432 (36%), Gaps = 62/432 (14%)
 Query: 239 LQGLQGNLAVSTGPQKVDYASGEISAGTAAGTKPTIALDTAALGMYADSITLIAHEK 298
 LQG LQGN+ + G + +G I A A K A + + S T +
 Sbjct: 1023 LQGLQGNIFAAAGSDITN--TGSIGAENALLK-----ASNIESRSETRSNQNE 1072
 Query: 299 GVGKVNAGTLEAAKQLIVTSSGRI--ENSGRIATTADGTEASPTYLXIETTEKGAXG-TF 355
 V+N G + A L +G + + I TA E T + G T
 Sbjct: 1073 QGSVRNIGRV-AGIYLTGRQNGSVLLDAGNNIVLTAS-----ELTNQSEDGQTV 1120
 Query: 356 ISNGGRIESKGLLVETGEDIXLRNGAVVQNGSRPATTVLNAGHNLVIESK-----T 408
 ++ GG I S + I + V++ + +T+ G NL + +K
 Sbjct: 1121 LNAGGDIRSDTTGISRNQNTIFDSDNYVIRKEQNEVGSTIRTRG-NLSLNAKGDIRIRAA 1179
 Query: 409 NVNNAKGSXNLSAGGRTTINDATIQAQSS-----VYSSTKGDXTLGENTRIIAENV 460
 V + +G L+AG D ++AG + Y+ G + TR +
 Sbjct: 1180 EVGSEQGR LKLAAG-----RDIKVEAGKAHTETEDALKYTGRSGGGIKQKMT RHLKNQNG 1234
 Query: 461 VLSNGSIGSAAVIEAKDTAHIESGKPLSLETSTVASNIRLNNGNIKGGKQLALLADDNIT 520
 +G++ +I +G + + T+ S NN +K + + A+ N
 Sbjct: 1235 QAVSGTLDGKEIILVSGRDTITVTGSNIADNHTILS--AKNNIVLKAETR SRSAEMNKK 1292
 Query: 521 AKTTNLTNTPG-NLYVHTGKDLNLNVDKDLASAASIHLSKSDN-----AAHITGTSKTLTA 572
 K+ + + G + KD N + +S + S N H T T T+++
 Sbjct: 1293 EKSGLMGSGGIGFTAGSKKDTQTNRSETVSHTESVVGSLNGNTLISAGKHYTQTGSTISS 1352
 Query: 573 SK-DMGVEAGXXXXXXXXXXXXSGNLHIQAAKG-----NIQLRNTKLNAAKALETALQG 626
 + D+G+ +G + + KG ++ + NT + A ++ G
 Sbjct: 1353 PQGDVGISSGKISIDAAQNRYSQESKQVYEKGVTVAISVPVNTVMGAVDAVKAVQTVG 1412
 Query: 627 NIVSDGLHAVSA 638
 + ++A++A
 Sbjct: 1413 KSKNSRVNMAA 1424

Amino acids 1-1423 of ORF114-1 were cloned in the pGex vector and expressed in *E.coli*, as described above. GST-fusion expression was visible using SDS-PAGE, and Figure 5 shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF114-1.

Based on these results, including the homology with the putative secreted protein of *N.meningitidis* and on the presence of a transmembrane domain, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 14

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 63>

1 ..CGCTTCATTC ATGATGAAGC AGTCGGCAGC AACATCGGCG GCGGCAAAAT
 51 GATTGTTGCA GCCGGGCAGG ATATCAATGT ACGCGGCAnA AGCCTTATTT
 101 CTGATAAGGG CATTGTTTTA AAAGCAGGAC ACGACATCGA TATTTCTACT
 151 GCCATAATC GCTATACCGG CAATGAATAC CACGAGAGCA wAAAwTCAGG
 5 201 CGTCATGGGT ACTGGCGGAT TGGGCTTTAC TATCGGTAAC CGGAAACTA
 251 CCGATGACAC TGATCGTACC AATATTGTsC ATACAGGCAG CATTATAGGC
 301 AGCCTGAaTG GAGACACCGT TACAGTTGCA GGAAACCGCT ACCGACAAAC
 351 CGGCAGTACC GTCTCCAGCC CCGAGGGGCG CAATACCGTC ACAGCCAAAw
 401 GCATAGATGT AGAGTTCGCA AACAAACCGGT ATGCCACTGA CTACGcCCAT
 10 451 ACCCAGgGGA CAAAAAGGCC TTACCGTCGC CCTCAATGTC CCGGTTGTGCC
 501 AAGCTGCACA AAACCTTCATA CAAGCAGCCC AAAATGTGGG CAAAAGTAAA
 551 AATAAACCGG TTAATGCCAT GGCTGCAGCC AATGTGTCAT GGCAGAGTTA
 601 TCAAGCAACC CAACAAATGC AACAAATTTGC TCCAAGCAGC AGTGCGGGAC
 651 AAGGTCAAAA CTACAATCAA AGCCCCAGTA TCAGTGTGTC CATTAC.TAC
 15 701 GCGCAACAGA AAAGTCGTAA CGAGCAAAAA AGACATTACA CCGAAgCGGC
 751 AgCAAGTCAA ATTATCGGCA AAGGGCAAAC CACACTTGCG GCAACAGGAA
 801 GTGGGGAGCA GTCCAATATC AATATTACAG GTTCCGATGT CATCGGCCAT
 851 GCAGGTACTC C.CTCATTGC CGACAACCAT ATCAGACTCC AATCTGCCAA
 901 ACAGGACGGC AGCGAGCAAA GCAAAAACAA AAGCAGTGGT TGGAAATGCAG
 20 951 GCGTACGTnn CAAAATAGGC AACGGCATCA GGTTTGGAAT TACCGCCGGA
 1001 GGAATATCG GTAAAGGTAA AGAGCAAGGG GGAAGTACTA CCCACCGCCA
 1051 CACCCATGTC GGCAGCACAA CCGGCAAAAC TACCATCGA AGCGCGGGG
 1101 GATACCACCC TCAAAGGTGT GCAGCTCATC GGCAAAGGCA TACAGGCAGA
 1151 TACGCGCAAC CTGCATATAG AAAGTGTTCa AGATACTGAA ACCTATCAGA
 25 1201 GCAAACAGCA AAACGGCAAT GTCCAAGTt ACTGTGGT ACGGATTACG
 1251 TGCAAGCGGC AGTTACCGCC AAAGCAAAGT CAAAGCAGAC CATGCTCCG
 1301 TAACCGGGCA AAgCGGTATT TATGCCGGAG AAGACGGCTA TCAAATyAAA
 1351 GTyAGAGACA ACACAGACCT yAAGGGCGGT ATCATCACGT CTAGCCAAAG
 1401 CGCAGAAGAT AAGGGCAAAA ACCTTTTTCA GACGGCCACC CTTACTGCCA
 30 1451 GCGACATTCA AAACCAACAG CGCTACGAAG GCAGAAGCTT CGGCATAGGC
 1501 GGCAGTTTCG ACCTGAACGG CGGCTGGGAC GGCACGGTTA CCGACAAACA
 1551 AGGCAGGCCT ACCGACAGGA TAAGCCCGGC AGCCGGCTAC GGCAGCGACG
 1601 GAGACAGCAA AAACAGCACC ACCCGCAGCG CGGTCAACAC CCACAACATA
 1651 CACATCACCG ACGAAGCGGG ACAACTTGCC CGAACAGGCA GGACTGCAAA
 35 1701 AGAAACCGAA GCGCGTATCT ACACCGGCAT CGACACCGAA ACTGCGGATC
 1751 AACACTCAGG CCATCTGAA AACAGCTTCG AC...

This corresponds to the amino acid sequence <SEQ ID 64; ORF116>:

1 ..RFIHDEAVGS NIGGGKMIVA AGQDINVRGX SLISDKGIVL KAGHDIDIST
 51 AHNRYTGNEY HESXXSGVMG TGGLGFTIGN RKTDDTDRT NIVHTGSIIG
 40 101 SLNGDTVTV GNRyRQTGST VSSPEGRNTV TAKXIDVEFA NNRYATDYAH
 151 TQEQKGLTVA LNVpVVQAAQ NFIOAAQNVG KSKNKRNVAM AAANAawQSY
 201 QATQQMQQFA PSSSAGQGQN YNQSPSISVS IXYPEQKSRN EQKRHYTEAA
 251 ASQIIGKQGT TLAATGSSEQ SNINITGSDV IGHAGTXLIA DNHIRLQSAK
 301 QDGSEQSKNK SSGWNAGVRX KIGNGIRFGI TAGGNIGKCK EQGGSTTHRH
 45 351 THVGSTTGKT TIRSGGDTTL KGVQLIGKGI QADTRNLHIE SVQDTETYS
 401 KQQNGNVQVT VGYGFSASGS YRQSKVKADH ASVTGQSGIY AGEDGYQIKV
 451 RDNTDLKGGI ITSSQSAEDK GKNLFQTATL TASDIQNHSR YEGRSFGIGG
 501 SFDLNGGWDG TVTDKQGRPT DRISPAAGYG SDGDSKNSTT RSGVNTNHII
 551 ITDEAGQLAR TGRTAKETEA RIYTGIDTET ADQHSGLHKN SFD...

50 Computer analysis of this amino acid sequence gave the following results:

Homology with pspA putative secreted protein of *N.meningitidis* (accession number AF030941)

ORF116 and pspA protein show 38% aa identity in 502aa overlap:

Orf116: 6 EAVGSNIGGGKMIVAAGQDINVRGXSLISDKGIVLKAGHDIDISTAHNRYTGNEYHESXX 65
 +AV + G ++I+ +G+DI V G ++I+D +L A ++I + A R E ++
 55 PspA: 1 235 QAVSGTLDGKEIILVSGRDITVTGSNIADNHTILSAKNNIVLKAETRSRSAEMNKKEK 1294
 Orf116: 66 XXXXXXXXXXXXXXXNRKXXXXXXXXRTNIVHTGSIIGSLNGDTVTVAGNRyRQTGSTVSSPE 125
 ++K + HT S++GSLNG+T+ AG Y QTGST+SSP+
 60 PspA: 1295 SGLMGSGGIGFTAGSKKDTQNRSETVSHTESVVGSLNGNTLISAGKHYTQTGSTISSPQ 1354

Orf116: 126 GRNTVTAKXIDVEFANNRYATDYAHTQEQKGLTVALNVPXXXX---XXXXXXXXXXXXGKS 182
 G +++ I ++ A NRY+ + EQKG+TVA++VP GKS
 PspA: 1355 GDVGISSGKISIDAAQNRYSQESKQVYEQKGVTVVAISVPVNTVMGAVDVAVKAVQTVGKS 1414

5 Orf116: 183 KNKRXXXXXXXWQSYQATQMQQFA--PSSSAGQGQNYNQSPSISVSIXYGEQKSRN 240
 KN RV + + + A P +AGQG ISVS+ YGEQK+ +
 PspA: 1415 KNSRVNMAAANALNKGVD SGVALYNAARNPKKAAGQG-----ISVSVTYGEQKNTS 1466

10 Orf116: 241 EQKRHYTEAAASQIIGKGQTLAATSGSEQSNINITGSDVIGHAGTXLIADNHIRLQSAK 300
 E + T+ +I G G+ +L A+G+G+ S I ITGSDV G GT L A+N ++++A+
 PspA: 1467 ESRIKGTQVQEGKITGGGKVS LTASGAGKDSRITITGSDVYGGKGT RLKAENAVQIEAAR 1526

15 Orf116: 301 QDGEQSKNKSSGWNAGVRXKIGNGIRFGITAXXXXXXXXXXXXXSTTHRHTHVGSTTGKT 360
 Q E+S+NKS+G+NAGV I GI FG TA T +R++H+GS +T
 PspA: 1527 QTHQERSENKSAGFNAGVAIAINKGISFGFTAGANYGKGYNDETAYRNSHIGSKDSQT 1586

20 Orf116: 361 TIRSGGDTTLKGVQLIGKGIQADTRNLHIESVQDTETYQSKQNGNVQVTVGYGFSASGS 420
 I SGGDT +KG QL GKG+ +LHIES+QDT ++ KQ+N + QVTVGYGFS GS
 PspA: 1587 AIESGGDTVIKGGQLKGGVGVTAESLHIESLQDTAVFKGQENVSAQVTVGYGFSVSGS 1646

25 Orf116: 421 YRQSKVKADHASVTGQSGIYAGEDGYQIKVRDNTDLKGGIITSSQSAEDKGKLNLFQTATL 480
 Y +SK +D+ASV QSGI+AG DGY+I+V T L G + S DK KNL +T+ +
 PspA: 1647 YNRKSSSDYASVNEQSGIFAGGDGYRIRVNGKTGLVGAHVSD---ADKSKNLLKTSEI 1703

Orf116: 481 TASDIQNHRSRYEGRSFGIGGSF 502
 DIQNH+ + G+ G F
 PspA: 1704 WHKDIQNHASAAASALGLSGGF 1725

Based on homology with *pspA*, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

30 Example 15

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 65>

35 1 ..ACGACCGGCA GCCTCGGCGG CATACTGGCC GCGGCGGCA CTTCCTTGC
 51 CGCACCGTAT TTGGACAAAG CGGCGGAAAA CCTCGGTCCG GCGGGCAAAG
 101 CGGCGGTCAA CGCACTGGGC GGTGCGGCCA TCGGCTATGC AACTGGTGGT
 151 AGTGGTGGTG CTGTGGTGGG TGCGAATGTA GATTGGAACA ATAGGCAGCT
 201 GCATCCGAAA GAAATGGCGT TGGCCGACAA ATATGCCGAA GCCCTCAAGC
 251 GCGAAGTTGA AAAACGCGAA GGCAGAAAA TCAGCAGCCA AGAAGCGGCA
 301 ATGAGAATCC GCAGGCAGAT ATGCGTTGGG TGGACAAAGG TTCCAAGAC
 351 GGCTATACCG ACCAAAGCGT CATATCCCTT ATCGGAATGA

40 This corresponds to the amino acid sequence <SEQ ID 66; ORF118>:

1 ..TGSLGGILA GGGTSLAOPY LDKAAENLGP AGKAAVNALG GAAIGYATGG
 51 SGGAVVGANV DWNRRQLHPK EMALADKYAE ALKREVEKRE GRKISSQEAA
 101 MRIRRQICVG WTKVPKTAIP TKASYPLSE*

Computer analysis of this amino acid sequence reveals two putative transmembrane domains.

45 Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 16

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 67>

1 ..CAATGCCGTC TGAAAAGCTC ACAATTTTAC AGACGGCATT TGTTATGCAA

51 GTACATATAC AGATTCCCTA TATACTGCCC AGrkGCGTGC GTgGCTGAAG
 101 ACACCCCTTA CGCTTGCTAT TTGrAACAGC TCCAAGTCAC CAAAGACGTC
 151 AACTGGAACC AGGTACwACT GCGGTACGAC AAATGGGACT ATAAACAGGA
 201 AGGCTTAACC GGAGCCGGAG CAGCGATTAT TGCGCTGGCT GTTACCGTGG
 5 251 TTAAGTGGGG CGCGGGAgCC GGAGCCGCAC TGGGcTAAA CGGCGCGGcC
 301 GCAGCGGCAA CCGATGCCGC ATTCGCCTCG CTGGCCAGCC AGGcTCCGT
 351 ATCGCTCATC AaCAACAAAG GCAATATCGG TAaCACCCCTG AAAGAGCTGG
 401 GCAGAAGCAG CACGGTGAAA AATCTGATGG TTGCCGTCGc tACCGCagGC
 10 451 GTagCgaCA AAATCGGTGC TTCGGCACTG AACAAATGTCA GCGATAAGCA
 501 GTGGATCAAC AACCTGACCG TCAACCTGGC CAATGCGGGC AGTGCCGCAC
 551 TGATTAATAC CGCTGTCAAC GGCGGCAGCc tgAAAGACAA TCTGGAAGCG
 601 AATATCCTTG CGGCTTTGGT GAATACTGCG CATGGAGAAG CAGCCAGTAA
 651 AATCAAACAG TTGGATCAGC ACTACATTAC CCACAAGATT GCCCaTGCCA
 701 TAGCGGGCTG TGCGGcTGCG GCGGCGAATA AGGGCAAGTG TCAGGATGGT
 15 751 GCGATAGGTG CGGCTGTGGG CGAGATAGTC GGGGAgGCTT TGACAACCGG
 801 CAAAAATCCT GACACTTTGA CAGCTAAAgA ACGCGaACAG ATTTTGGCAT
 851 ACAGCAAACCT GGTGCGCGGT ACGGTAAGCG GTGTGGTCCG CGGCGATGTA
 901 AATGCGGCGG CGAATGCGGC TGAGGTAGCG GTGAAAAATA ATCAGCTTAG
 951 CGACAAAtGA

20 This corresponds to the amino acid sequence <SEQ ID 68; ORF41>:

1 ..QCRLKSSQFY RRHLLCKYIY RFPIYCPXAC VAEDTPYACY LXQLQVTKDV
 51 NWNQVXLAYD KWDYKQEGLT GAGAAIILA VTVVTAGAGA GAALGLNGAA
 101 AAATDAAFAS LASQASVSLI NNKGNIGNTL KELGRSSTVK NLMVAVATAG
 151 VADKIGASAL NNVSDKQWIN NLTVNLANAG SAALINTAVN GGSLLKDNLEA
 25 201 NILAALVNTA HGEAASKIKQ LDQHYITHKI AHAIAGCAAA AANKGKCQDG
 251 AIGAAVGEIV GEALTNGKNP DTLTKEREQ ILAYSKLVAG TVSGVVGGDV
 301 NAAANAEEVA VKNNQLSDK*

Further work revealed the complete nucleotide sequence <SEQ ID 69>:

1 ATGCAAGTAA ATATTCAGAT TCCCTATATA CTGCCAGAT GCGTGCGTGC
 30 51 TGAAGACACC CCTACGCTT GCTATTTGAA ACAGCTCAA GTCAACCAAG
 101 ACGTCAACTG GAACCAGGTA CAACTGGCGT ACGACAAATG GGACTATAAA
 151 CAGGAAGGCT TAACCGGAGC CGGAGCAGCG ATTATTGCGC TGCTGTATAC
 201 CGTGGTTACT GCGGGCGCGG GAGCCGAGC CGCACTGGGC TTAACGGCGC
 251 CGGCGCGAGC GGCAACCGAT GCCGCATTG CCTCGCTGGC CAGCCAGGCT
 35 301 TCCGTATCGC TCATCAACAA CAAAGGCAAT ATCGGTAACA CCCTGAAAGA
 351 GCTGGGCGA AGCAGCAGCG TGAATAATCT GATGGTTGCC GTCGCTACCG
 401 CAGGCGTAGC GACAAAAATC GGTGCTTCGG CACTGAACAA TGTGAGGAT
 451 AAGCAGTGGG TCAACAACCT GACCGTCAAC CTGGCCAATG CGGGCAGTGC
 501 CGCACTGATT AATACCGCTG TCAACGGCGG CAGCCTGAAA GACAATCTGG
 40 551 AAGCGAATAT CCTTGGCGCT TTGGTGAATA CTGCGCATGG AGAAGCAGCC
 601 AGTAAAAATCA AACAGTTTGA TCAGCACTAC ATTACCCACA AGATTGCCCA
 651 TGCCATAGCG GGTGTGCGG CTGCGGCGGC GAATAAGGGC AAGTGTCAAG
 701 ATGGTGCAT AGGTGCGGCT GTGGGCGAGA TAGTCGGGGA GGCTTTGACA
 45 751 AACGGCAAAA ATCTGACAC TTTGACAGCT AAAGAACGCG AACAGATTTT
 801 GGCATACAGC AAATCGGTTG CCGGTACGGT AAGCGGTGTG GTCGGCGGCG
 851 ATGTAAATGC GCGGCGAAT GCGGCTGAGG TAGCGGTGAA AAATAATCAG
 901 CTTAGCGACA AAGAGGGTAG AGAATTTGAT AACGAAATGA CTGCATGCGC
 951 CAAACAGAAT AATCCTCAAC TGTGCAGAAA AAATACTGTA AAAAAGTATC
 1001 AAAATGTTGC TGATAAAGA CTTGCTGCTT CGATTGCAAT ATGTACGGAT
 50 1051 ATATCCCGTA GTACTGAATG TAGAACAATC AGAAAAACA ATTGTATCGA
 1101 TAGTAGAAGC CTTCAATCAT CTTGGGAAGC AGGTCTAAT GGTAAAGATG
 1151 ATGAATGGTA TAAATTATC AGCAAACTT ACACCCAAGC AGATTGGCT
 1201 TTACAGTCTT ATCATTGAA TACTGCTGCT AAATCTTGGC TTCAATCGGG
 1251 CAATACAAAG CCTTTATCCG AATGGATGTC CGACCAAGGT TATACACTTA
 55 1301 TTTCAAGAGT TAATCCTAGA TTCAATCCAA TACCAAGAGG GTTTGTAAAA
 1351 CAAATACAC CTATTACTAA TGTCAAATAC CCGGAAGGCA TCAGTTTCGA
 1401 TACAAACCTA AAAAGACATC TGGCAAATGC TGATGGTTTT AGTCAAAAAC
 1451 AGGGCATTAA AGGAGCCCAT AACCGCACCA ATTTTATGGC AGAACTAAAT
 1501 TCACGAGGAG GACGCGTAAA ATCTGAAACC CAACTGATA TTGAAGGCAT
 60 1551 TACCGAATT AAATATGAGA TTCCTACACT AGACAGGACA GGTAAACCTG
 1601 ATGGTGGATT TAAGGAAAT TCAAGTATAA AAATGTTTA TAATCCTAAA
 1651 AAATTTCTG ATGATAAAAT ACTTCAAATG GCTCAAATG CTGCTTCA
 1701 AGGATATTCA AAAGCCTCTA AAATTGCTCA AAATGAAAGA ACTAAATCAA
 1751 TATCGGAAAG AAAAATGTG ATTCAATTCT CAGAAACCTT TGACGGAATC
 65 1801 AAATTTAGAT CATATTTTGA TGTAATACA GGAAGAATTA CAAACATTCA
 1851 CCCAGAATAA

This corresponds to the amino acid sequence <SEQ ID 70; ORF41-1>:

```

      1  MQVNIQIPYI  LPRCVRAEDT  PYACYLKQLQ  VTKDVNWNQV  QLAYDKWDYK
    51  QEGLTGAGAA  IIALAVTVVT  AGAGAGAALG  LNGAAAAATD  AAFASLASQA
   101  SVSLINNKN  IGNTLKELEGR  SSTVKNLMA  VATAGVADKI  GASALNNVSD
   151  KQWINNLT  VN LANAGSAAL  NTAVNGGSLK  DNLEANILAA  LVNTAHGEAA
   201  SKIKQLDQHY  ITHKIAHAIA  GCAAAAANKG  KCQDGAIGAA  VGEIVGEALT
   251  NGKNPDTLTA  KEREQILAYS  KLVAGTVSGV  VGGDVNAAN  AAEVAVKNQ
   301  LSDKEGREFD  NEMTACAKQN  NPQLCRKNTV  KKYQNVADKR  LAASIAICTD
   351  ISRSTECRTI  RKQHLIDSRS  LHSSWEAGLI  GKDDEWYKLF  SKSYTQADLA
   401  LQSYHLNTAA  KSWLQSGNTK  PLSEWMSDQG  YTLISGVNPR  FPIPIRGFVK
   451  QNTPITNVKY  PEGISFDTNL  KRHLANADGF  SQKQGIKGAH  NRTNFMALN
   501  SRGGRVKSET  QTDIEGITRI  KYEIPTLDRT  GKPDGGFKEI  SSIKTVYNPK
   551  KFSDDKILQM  AQNAASQGY  KASKIAQNER  TKSISERKNV  IQFSETFDGI
   601  KFRSYFDVNT  GRITNIHPE*

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- 15 Computer analysis of this amino acid sequence predicts a transmembrane domain, and homology with an ORF from *N.meningitidis* (strain A) was also found.

ORF41 shows 92.8% identity over a 279aa overlap with an ORF (ORF41a) from strain A of *N.meningitidis*:

```

20  orf41.pep      10      20      30      40      50      60      69
    YRRHLLCKYIYRFPIYCPXACVAEDTPYACYLXQLQVTKDVNWNQVXLAYDKWDYKQEGL
    orf41a                                YLKQLQVAKNINWNQVQLAYDRWDYKQEGL
                                         10      20      30

25  orf41.pep      70      80      90      100     110     120     129
    TGAGAAIIALAVTVVTAGAGAGAALGLNGAAAAATDAAFASLASQASVSLINNKNIGNT
    orf41a          TEAGAAIIALAVTVVTSGAGTGAVLGLNGAXAAATDAAFASLASQASVFINNKGDVGKT
                      40      50      60      70      80      90

30  orf41.pep     130     140     150     160     170     180     189
    LKELGRSSTVKNLMVAVATAGVADKIGASALNNVSDKQWINNLTVNLANAGSAALINTAV
    orf41a          LKELGRSSTVKNLVVAAATAGVADKIGASALXNVSDKQWINNLTVNLANAGSAALINTAV
                      100     110     120     130     140     150

35  orf41.pep     190     200     210     220     230     240     249
    NGGSLKDNLEANILAAVNTAHGEAASKIKQLDQHYITHKIAHAIAAGCAAAAANKGKCQD
    orf41a          NGGSLKDXLEANILAAVNTAHGEAASKIKQLDQHYIVHKIAHAIAAGCAAAAANKGKCQD
                      160     170     180     190     200     210

40  orf41.pep     250     260     270     280     290     300     309
    GAIGAAVGEIVGEALTNGKNPDTLTAKEREQILAYSCLVAGTVSGVVGGDVNAANAAEV
    orf41a          GAIGAAVGEIVGEALTNGKNPDTLTAKEREQILAYSCLVAGTVSGVVGGDVNAANAAEV
                      220     230     240     250     260     270

45  orf41.pep     310     320
    AVKNNQLSDKX
    orf41a          AVKNNQLSDXEGREFDNEMTACAKQNPQLCRKNTVKKYQNVADKRLAASIAICTDISRS
                      280     290     300     310     320     330

```

A partial ORF41a nucleotide sequence <SEQ ID 71> is:

```

55      1  ..TATCTGAAAC  AGCTCCAAGT  AGCGAAAAAC  ATCAACTGGA  ATCAGGTGCA
    51  GCTTGCTTAC  GACAGATGGG  ACTACAAACA  GGAGGGCTTA  ACCGAAGCAG
   101  GTGCGGCGAT  TATCGCACTG  GCCGTTACCG  TGGTCACCTC  AGGCGCAGGA
   151  ACCGGAGCCG  TATTGGGATT  AAACGGTGCG  NCCGCCGCCG  CAACCGATGC

```

201 AGCATTTCGCC TCTTTGGCCA GCCAGGCTTC CGTATCGTTC ATCAACAACA
 251 AAGGCGATGT CGGCAAAACC CTGAAAGAGC TGGGCAGAAAG CAGCACGGTG
 301 AAAAATCTGG TGGTTGCCGC CGCTACCGCA GGCCTAGCCG ACAAATCTGG
 351 CGCTTCGGCA CTGANCAATG TCAGCGATAA GCAGTGGATC AACAACTGTA
 5 401 CCGTCAACCT AGCCAATGCG GGCAGTGGCG CACTGATTAA TACCGCTGTC
 451 AACGGCGGCA GCCTGAAAGA CANTCTGGAA GCGAATATCC TTGCGGCTTT
 501 GGTCAATACC GCGCATGGAG AAGCAGCCAG TAAAATCAA CAGTTGGATC
 551 AGCACTACAT AGTCCACAAG ATTGCCCATG CCATAGCGGG CTGTGCGGCA
 601 GCGGCGGCGA ATAAGGGCAA GTGTCAGGAT GGTGCGATAG GTGCGGCTGT
 10 651 GGGCGAGATA GTCGGGGAGG CTTTGACAAA CGGCAAAAT CCTGACACTT
 701 TGACAGCTAA AGAACGCGAA CAGATTTTGG CATACAGCAA ACTGGTTGCC
 751 GGTACGGTAA GCGGTGTGGT CGGCGGCGAT GTAAATGCGG CGGCGAATGC
 801 GGTGAGGTA GCGGTGAAAA ATAATCAGCT TAGCGACNAA GAGGGTAGAG
 851 AATTTGATAA CGAAATGACT GCATGCGCCA AACAGAATAN TCCTCAACTG
 15 901 TGCAGAAAAA ATACTGTAAA AAAGTATCAA AATGTTGCTG ATAAAAGACT
 951 TGCTGCTTCG ATTGCAATAT GTACGGATAT ATCCCGTAGT ACTGAATGTA
 1001 GAACAATCAG AAAACAACAT TTGATCGATA GTAGAAGCCT TCATTATCTT
 1051 TGGGAAGCAG GTCTAATTGG TAAAGATGAT GAATGGTATA AATTATTCAG
 1101 CAAATCTTAC ACCCAAGCAG ATTTGGCTTT ACAGTCTTAT CATTGATAA
 20 1151 CTGCTGCTAA ATCTTGGCTT CAATCGGGCA ATACAAAGCC TTTATCCGAA
 1201 TGGATGTCCG ACCAAGGTTA TACACTTATT TCAGGAGTTA ATCCTAGATT
 1251 CATTCCAATA CCAAGAGGGT TTGTAAAAA AAATACACCT ATACTAATG
 1301 TCAAATACCC GGAAGGCATC AGTTTCGATA CAAACCTANA AAGACATCTG
 1351 GCAAAATGCTG ATGGTTTTAG TCAAGAACAG GGCATTAAAG GAGCCCATAA
 25 1401 CCGCACCAAT NTTATGGCAG AACTAAATTC ACGAGGAGGA NGNGTAAAT
 1451 CTGAAACCCA NACTGATATT GAAGGCATTA CCCGAATTAA ATATGAGATT
 1501 CCTACACTAG ACAGGACAGG TAAACCTGAT GGTGGATTTA AGGAAATTC
 1551 AAGTATAAAA ACTGTTTATA ATCCTAAAAA NTTTNNNGAT GATAAAATAC
 30 1601 TTCAAATGCG TCAANATGCT GNTTCACAAG GATATTCAA AGCCTCTAAA
 1651 ATTGCTCAA ATGAAAGAAC TAAATCAATA TCGGAAAGAA AAAATGTCAT
 1701 TCAATTCTCA GAAACCTTTG ACGGAATCAA ATTAGANNN TATNTNGATG
 1751 TAAATACAGG AAGAATTACA AACATTACC CAGAATAA

This encodes a protein having the partial amino acid sequence <SEQ ID 72>:

1 YLKQLQVAKN INWNQVQLAY DRWDYKQEGL TEAGAAIAL AVTVVTSAG
 35 51 TGAVLGLNGA XAAATDAFA SLASQASVSF INNKGVDVGT LKELGRSSTV
 101 KNLVVAATA GVADKIGASA LXNVSDKQWI NNLTVNLANA GSAALINTAV
 151 NGGSLKDXLE ANILAALVNT AHGEAASKIK QLDQHYIVHK IAHAIAGCAA
 201 AAANKGKCQD GAIGAAVGEI VGEALTNGKN PDTLTAKERE QILAYSKLVA
 251 GTVSGVVGDD VNAAANAAEV AVKNNQLSDX EGREFDNEMT ACAKQNXPL
 40 301 CRKNTVKKYQ NVADKRLAAS IAICTDISRS TECRTIRKQH LIDSRSLHSS
 351 WEAGLIGKDD EWYKLFKSY TQADLALQSY HLNTAAKSWL QSGNTKPLSE
 401 WMSDQGYTLI SGVNPRFIPI PRGEVKQNTPT ITNVKYPEGI SFDNLXRHL
 451 ANADGFSQEQ GIKGAHNRTN XMAELNSRGG XVKSETXTDI EGITRIKYEI
 501 PTLDRGTGKPD GGFKEISSIK TVYNPKXFXD DKILQMAQXA XSQYSKASK
 45 551 IAQNERTKSI SERKNVIQFS ETFDGIKFRX YXDVTNGRIT NIHPE*

ORF41a and ORF41-1 show 94.8% identity in 595 aa overlap:

orf41a.pep 10 20 30
 YLKQLQVAKNINWNQVQLAYDRWDYKQEGLTEAGAA
 50 orf41-1 MQVNIQIPYILPRCVRAEDTPYACYLKQLQVTKDVNWNQVQLAYDKWDYKQEGLTGAGAA
 10 20 30 40 50 60
 orf41a.pep 40 50 60 70 80 90
 IIALAVTVVTSAGTGAVLGLNGAXAAATDAAFASLASQASVSFINNKGVDVGTLLKELGR
 55 orf41-1 IIALAVTVVTAGAGAGAALGLNGAAAAATDAAFASLASQASVSLINNKGNIINTLTKELGR
 70 80 90 100 110 120
 orf41a.pep 100 110 120 130 140 150
 SSTVKNLVVAATAGVADKIGASALXNVSDKQWNNLTVNLNAGSAAALINTAVNGGSLK
 60 orf41-1 SSTVKNLMVAVATAGVADKIGASALNNVSDKQWNNLTVNLNAGSAAALINTAVNGGSLK
 130 140 150 160 170 180
 65 orf41a.pep 160 170 180 190 200 210
 DXLEANILAAALVNTAHGEAASKIKQLDQHYIVHKIAHAIAAGCAAAAANKGKCQDGAIGAA

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

50 Example 17

The following DNA sequence was identified in *N.meningitidis* <SEQ ID 73>

55

1	ATGGCAATCA	TTACATTGTA	TTATTCTGTC	AATGGTATTT	TAAATGTATG
51	TGCAAAAGCA	AAAAATATTC	AAGTAGTTGC	CAATAATAAG	AATATGGTTC
101	TTTTTGGGTT	TTTGGsmrGC	ATCATCGGCG	GTTCAACCAA	TGCCATGTCT
151	CCCATTATTGT	TAAATTATTT	GCTTAGCGAA	ACAGAAAATA	AAAATcgTAT
201	CGTAAAATCA	AGCAATCTAT	GCTATCTTTT	GGCGAAAATT	GTTCAAAAT
251	ATATGCTAAG	AGACCAATAT	TGGTTATTAA	ATAAGAGTGA	ATACGdTTTA
301	ATATTTTTAC	TGTCGGTATT	GTCTGTTATT	GGATTGTATG	TTGGAATTCG
351	GTTAAGGACT	AAGATTAGCC	CAaATTTTTT	TAAATGTGTA	ATTTTATTTG

401 tTTTATTGGT ATTGGCtCTG AAAATCGGGC AttCGGGTTT AatCAAACCTT
451 TAA

This corresponds to the amino acid sequence <SEQ ID 74; ORF51>:

5 1 MAIITLYYSV NGILNVCACA KNIQVVANNK NMVLFGLX IIGGSTNAMS
 51 PILLIFLLSE TENKNRIVKS SNLCYLLAKI VQIYMLRDQY WLLNKSEYXL
 101 IFLLSVLSVI GLYVGIRLRT KISPNEFKML IFIVLLVLAL KIGHSGLIKL
 151 *

Further work revealed the complete nucleotide sequence <SEQ ID 75>:

10 1 ATGCAAGAAA TAATGCAATC TATCGTTTTT GTTGCTGCCG CAATACTGCA
 51 CGGAATTACA GGCATGGGAT TTCCGATGCT CGGTACAACC GCATTGGCCTT
 101 TTATCATGCC ATTGCTAAG GTTGTGCCT TGGTGGCATT ACCAAGCCTG
 151 TTAATGAGCT TGTGGTTCT ATGCAGCAAT AACAAAAAGG GTTTTGGCA
 201 AGAGATTGTT TATTATTTAA AAACCTATAA ATTGCTTGCT ATCGGCAGCG
 251 TCGTTGGCAG CATTTTGGGG GTGAAGTTGC TTTTGATACT TCCAGTGTCT
 15 301 TGGCTGCTTT TACTGATGGC AATCATTACA TTGTATTATT CTGTCAATGG
 351 TATTTTAAAT GTATGTGCAA AAGCAAAAAA TATTCAAGTA GTTGCCAATA
 401 ATAAGAATAT GGTCTTTTTT GGGTTTTTGG CAGGCATCAT CGGCGGTTCA
 451 ACCAATGCCA TGTCTCCCAT ATTGTTAATA TTTTGTCTTA GCGAAACAGA
 501 AAATAAAAAAT CGTATCGTAA AATCAAGCAA TCTATGCTAT CTTTGGCGA
 20 551 AAATTGTTCA AATATATATG CTAAGAGACC AGTATGGTT ATTAAATAAG
 601 AGTGAATACG GTTTAATATT TTTACTGTCC GTATGTCTG TTATTGGATT
 651 GTATGTTGGA ATTCGGTTAA GGACTAAGAT TAGCCCAAAT TTTTAAAAA
 701 TGTTAATTTT TATTGTTTAA TTGGTATTGG CTCTGAAAAT CGGGCATTGC
 751 GGTTTAATCA AACTTTAA

25 This corresponds to the amino acid sequence <SEQ ID 76; ORF51-1>:

 1 MOEIMQSIVF VAAAILHGIT GMGFPMLGTT ALAFIMPLSK VVALVALPSL
 51 LMSLLVLCNS NKKGFQEIY YLKYTKLLA IGSVVSILG VKLLILPVS
 101 WLLLLMAIIT LYYSVNGILN VCAKAKNIQV VANNKNMVLG GFLAGIIGGS
 151 TNAMESPILLI FLLSETENKN RIVKSSNLGY LLAKIVQIYM LRDQYWLLNK
 201 SEYGLIFLLS VLSVIGLYVG IRLRTKISPN FFKMLIFIVL LVLALKIGHS
 251 GLIKL*

Computer analysis of this amino acid sequence reveals three putative transmembrane domains. A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

35 ORF51 shows 96.7% identity over a 150aa overlap with an ORF (ORF51a) from strain A of *N.meningitidis*:

					10	20	30
orf51.pep					MAIITLYYSV	NGILNVCACA	KNIQVVANNK
40 orf51a	YKLLAIGSVVGSILGVKLLILPVS	WLLLLMAIITLYYSV	NGILNVCACA	KNIQVVANNK			
	80	90	100	110	120	130	
		40	50	60	70	80	90
orf51.pep	NMVLFGLX	IIIGGSTNAMS	PILLIFLLSE	TENKNRIVKS	SNLCYLLAKI	VQIYMLRDQY	
45 orf51a	NMVLFGLAGI	IIIGGSTNAMS	PILLIFLLSE	TENKNRIAKS	SNLCYLLAKI	VQIYMLRDQY	
	140	150	160	170	180	190	
	100	110	120	130	140	150	
orf51.pep	WLLNKSEYGL	IFLLSVLSVIGLYVG	IRLRTKISPN	FFKMLIFIVL	LVLALKIGHSGLIKL		
50 orf51a	WLLNKSEYGL	IFLLSVLSVIGLYVG	IRLRTKISPN	FFKMLIFIVL	LVLALKIGHSGLIKL		
	200	210	220	230	240	250	

ORF51-1 and ORF51a show 99.2% identity in 255 aa overlap:

```

5  orf51a.pep  MQEIMQSIVFVAAAILHGITGMGFMLGTTALAFIMPLSKVVALVALPSLLMSLLVLCSN
   orf51-1    MQEIMQSIVFVAAAILHGITGMGFMLGTTALAFIMPLSKVVALVALPSLLMSLLVLCSN

10 orf51a.pep  NKKGFWQEIVYYLKYKLLAIGSVVGSILGVKLLLLILPVSWLLLLMAIITLYYSVNGILN
   orf51-1    NKKGFWQEIVYYLKYKLLAIGSVVGSILGVKLLLLILPVSWLLLLMAIITLYYSVNGILN

15 orf51a.pep  VCAKAKNIQVVANNKNMVLFGFLAGIIGGSTNAMSPELLIFLLSETENKNRIAKSSNLGY
   orf51-1    VCAKAKNIQVVANNKNMVLFGFLAGIIGGSTNAMSPELLIFLLSETENKNRIKSSNLGY

20 orf51a.pep  LLAIVQIYMLRDQYLLNKSEYGLIFLLSVLSVIGLYVGIRLRTKISPNFFKMLIFIVL
   orf51-1    LLAIVQIYMLRDQYLLNKSEYGLIFLLSVLSVIGLYVGIRLRTKISPNFFKMLIFIVL

   orf51a.pep  LVLALKIGYSGLIKLX
20 orf51-1    LVLALKIGHSGLIKLX

```

The complete length ORF51a nucleotide sequence <SEQ ID 77> is:

```

1  ATGCAAGAAA TAATGCAATC TATCGTTTTT GTTGCTGCCG CAATACTGCA
51 CGGAATTACA GGCATGGGAT TTCCGATGCT CGGTACAACC GCATTGGCCT
25 101 TTATCATGCC ATTGTCTAAG GTTGTGCCT TGGTGGCATT ACCAAGCCTG
   151 TTAATGAGCT TGTGGTCTCT ATGCAGCAAT AACAAAAAGG GTTTTGGCA
   201 AGAGATTGTT TATTATTTAA AAACCTATAA ATTGCTTGCT ATCGGCAGCG
   251 TCGTTGGCAG CATTGTGGGG GTGAAGTTGC TTTTGATACT TCCAGTGTCT
   301 TGGCTGCTTT TACTGATGGC AATCATTACA TTGTATTATT CTGTCAATGG
   351 TATTTTAAAT GTATGTGCAA AAGCAAAAAA TATTCAAGTA GTTGCCAATA
30 401 ATAAGAATAT GGTTCCTTTT GGGTTTGTGG CAGGCATCAT CGGCGGTTCA
   451 ACCAATGCCA TGTCTCCCAT ATTGTTAATA TTTTGCCTTA GCGAACACAGA
   501 GAATAAAAAAT CGTATCGCAA AATCAAGCAA TCTATGCTAT CTTTGGCAA
   551 AAATTGTTCA AATATATATG CTAAGAGACC AGTATGGTT ATTAAATAAG
35 601 AGTGAATACG GTTTAATATT TTTACTGTCC GTATTGTCTG TTATTGGATT
   651 GTATGTTGGA ATTCGGTTAA GGACTAAGAT TAGCCCAAAT TTTTAAAAA
   701 TGTTAATTTT TATTGTTTAA TTGGTATTGG CTCTGAAAAT CGGGTATTCA
   751 GGTTTAATCA AACTTTAA

```

This encodes a protein having amino acid sequence <SEQ ID 78>:

```

40 1  MQEIMQSIVF VAAAILHGIT GMGFMLGTT ALAFIMPLSK VVALVALPSL
   51  LMSLLVLCSN NKKGFWQEIV YYLKTYKLLA IGSVVGSILG VKLLLLILPV
   101 WLLLLMAIIT LYYSVNGILN VCAKAKNIQV VANNKNMVLFG FLAGIIGGS
   151 TNAMSPILLI FLLSETENKN RIAKSSNLGY LLAIVQIYM LRDQYLLNK
   201 SEYGLIFLLS VLSVIGLYVG IRLRTKISPN FFKMLIFIVL LVLALKIGYS
   251 GLIKL*

```

45 Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 18

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 79>

```

50 1  ATGAGACATA TGAAAATACA AAATTATTTA CTAGTATTTA TAGTTTACAA
   51  TATAGCCTTG ATAGTAATTA ATATAGTGTG TGGTTATTTT GTTTTCTAT
   101 TTGATTTTTT TCGTTTTTTG TTTTTGCAA ACGTCTTCT TGCTGTAAT
   151 TTATTATTTT TAGAAAAAAA CATAAAAAAC AAATTATTGT TTTTATTGCC
   201 GATTTCTATT ATTATATGGA TGGTAATTCA TATTAGTATG ATAAATATAA
55 251 AATTTTATAA ATTTGAGCAT CAAATAAAGG AACAAAATAT ATCCTCGATT
   301 ACTGGGGTGA TAAACCACA TGATAGTTAT AATTATGTTT ATGACTCAAA

```

```

351 TGGATATGCT AAATTAAG ATAATCATAG ATATGGTAGG GTAATTAGAG
401 AAACACCTTA TATTGATGTA GTTGCATCTG ATGTTAAAAA TAAATCCATA
451 AGATTAAGCT TGGTTGTGG TATTCATTCA TATGCTCCAT GTGCCAATT
501 TATAAAATTT GTCAGG..

```

5 This corresponds to the amino acid sequence <SEQ ID 80; ORF82>:

```

1 MRHMKIONYL LVFIVLHIAL IVINIVFGYF VFLDFFFAEL FFANVFLAVN
51 LLFLEKNIKN KLLFLLPISI IIWMVIHISM INIKFYKFEH QIKEQNISSI
101 TGVKPHDSY NYVDSNGYA KLKDNHRYGR VIRETPYIDV VASDVKNKSI
151 RLSLVCGIHS YAPCANFIKF VR..

```

10 Further work revealed the complete nucleotide sequence <SEQ ID 81>:

```

1 ATGAGACATA TGAAAAATAA AAATTATTTA CTAGTATTTA TAGTTTTACA
51 TATAGCCTTG ATAGTAATTA ATATAGTGTG TGGTTATTTT GTTTTCTAT
101 TTGATTTTTT TGCCTTTTGT TTTTGTGCAA ACGTCTTTCT TGCTGTAAAT
151 TTATTATTTT TAGAAAAAAA CATAAAAAAC AAATTATGTG TTTTATTGCC
15 GATTTCTATT ATTATATGGA TGGTAATTCA TATTAGTATG ATAAATATAA
201 AATTTTATAA ATTTGAGCAT CAAATAAAGG AACAAAATAT ATCCTCGATT
251 ACTGGGGTGA TAAAACCACA TGATAGTTAT AATTATGTTT ATGACTCAAA
301 TGGATATGCT AAATTAAG ATAATCATAG ATATGGTAGG GTAATTAGAG
351 AAACACCTTA TATTGATGTA GTTGCATCTG ATGTTAAAAA TAAATCCATA
401 AGATTAAGCT TGGTTGTGG TATTCATTCA TATGCTCCAT GTGCCAATTT
20 TATAAAATTT GCAAAAAAAC CTGTTAAAT TTTTATTTAT AATCAACCTC
501 AAGGAGATT TATAGATAAT GTAATATTG AAATTAATGA TGGAAACAAA
551 AGTTTGTACT TGTTAGATAA GTATAAACA TTTTCTTA TTGAAACAG
601 TGTTGTATC GTATTAATTA TTTTATATT AAAATTTAAT TTGCTTTTAT
651 ATAGGACTTA CTCAATGAG TTGGAATAG
701

```

This corresponds to the amino acid sequence <SEQ ID 82; ORF82-1>:

```

1 MRHMKKNKYL LVFIVLHIAL IVINIVFGYF VFLDFFFAEL FFANVFLAVN
51 LLFLEKNIKN KLLFLLPISI IIWMVIHISM INIKFYKFEH QIKEQNISSI
101 TGVKPHDSY NYVDSNGYA KLKDNHRYGR VIRETPYIDV VASDVKNKSI
30 RLSLVCGIHS YAPCANFIKF AKKPKIYFY NQPGDFIDN VIFEINDGNK
201 SLYLLDKYKT FFLIENSVCV VLIIYLKFN LLYRTYFNE LE*

```

Computer analysis of this amino acid sequence reveals a predicted leader peptide.

A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

35 ORF82 shows 97.1% identity over a 172aa overlap with an ORF (ORF82a) from strain A of *N.meningitidis*:

		10	20	30	40	50	60
orf82.pep		MRHMKIONYLLVFIVLHIALIVINIVFGYFVFLDFFFAELFFANVFLAVN	LLFLEKNIKN				
40	orf82a	MRHMKKNKYL/VFIVLHITLIVINIVFGYFVFLDFFFAELFFANVFLAVN	LLFLEKNIKN				
		10	20	30	40	50	60
		70	80	90	100	110	120
orf82.pep		KLLFLLPISIIWMVIHISM INIKFYKFEHQIKEQNISSITGVKPHDSYNYVDSNGYA					
45	orf82a	KLLFLLPISIIWMVIHISM INIKFYKFEHQIKEQNISSITGVKPHDSYNYVDSNGYA					
		70	80	90	100	110	120
		130	140	150	160	170	
50	orf82.pep	KLKDNHRYGRVIRETPYIDVVASDVKNKSIRLSLVCGIHSYAPCANFIKFR					
	orf82a	KLKDNHRYGRVIRETPYIDVVASDVKNKSIRLSLVCGIHSYAPCANFIKFAKKPKIYFY					
		130	140	150	160	170	180

ORF82a and ORF82-1 show 99.2% identity in 242 aa overlap:

```

    orf82a.pep  MRHMKNKNYLLVFIVLHITLIVINIVFGYFVFLDFFAELFFANVFLAVNLLFLEKNIKN
    orf82-1      MRHMKNKNYLLVFIVLHIALIVINIVFGYFVFLDFFAELFFANVFLAVNLLFLEKNIKN
5
    orf82a.pep  KLLFLLPISIIWMVIHISMINIKFYKFEHQIKEQNISSITGVIKPHDSYNYVYDSNGYA
    orf82-1      KLLFLLPISIIWMVIHISMINIKFYKFEHQIKEQNISSITGVIKPHDSYNYVYDSNGYA
10
    orf82a.pep  KLKDNHRYGRVIRETPYIDVVASDVKNKSIRLSLVCGIHSYAPCANFIKFAKKPVKIYFY
    orf82-1      KLKDNHRYGRVIRETPYIDVVASDVKNKSIRLSLVCGIHSYAPCANFIKFAKKPVKIYFY
15
    orf82a.pep  NQPQGD FIDNVIFEINDGKKS LYLDDKYKTF FLIENSVCI VLIILYLKFN LLLYRTYFNE
    orf82-1      NQPQGD FIDNVIFEINDGKKS LYLDDKYKTF FLIENSVCI VLIILYLKFN LLLYRTYFNE
20
    orf82a.pep  LEX
    orf82-1      LEX

```

The complete length ORF82a nucleotide sequence <SEQ ID 83> is:

```

1  ATGAGACATA TGAAAAATAA AAATTATTTA CTAGTATTTA TAGTTTTACA
51 TATAACCTTG ATAGTAATTA ATATAGTGTT TGGTTATTTT GTTTTTCTAT
25 101 TTGATTTTTT TGC GTTTTTG TTTTGTGCAA ACGTCTTTCT TGCTGTA AAT
151 TTATTATTTT TAGAAAAAAA CATAAAAAAC AAATTATTGT TTTTATTGCC
201 GATTCTATAT ATTATATGGA TGGTAATTCA TATTAGTATG ATAAATATAA
251 AATTTTATAA ATTTGAGCAT CAAATAAAGG AACAAAATAT ATCCTCGATT
301 ACTGGGGTGA TAAACCACA TGATAGTTAT AATTATGTTT ATGACTCAA
30 351 TGGATATGCT AAATTA AAG ATAATCATAG ATATGGTAGG GTAATTAGAG
401 AAACACCTTA TATTGATGTA GTTGCATCTG ATGTTAAAAA TAAATCCATA
451 AGATTAAGCT TGGTTTGTGG TATTCATTCA TATGCTCCAT GTGCCAATTT
501 TATAAAATTT GCAAAAAAAC CTGTTAAAT TATTTTAT AATCAACCTC
551 AAGGAGATTT TATAGATAAT GTAATATTG AAATTAATGA TGGAAAAAAA
35 601 AGTTGTACT TGTTAGATAA GTATAAACA TTTTCTTA TTGAAACAG
651 TGTTGTATC GTATTAATTA TTTTATATT AAAATTTAAT TTGCTTTTAT
701 ATAGGACTTA CTTCAATGAG TTGGAATAG

```

This encodes a protein having amino acid sequence <SEQ ID 84>:

```

1  MRHMKNKNYL LVFIVLHITL IVINIVFGYF VFLDFFAEL FFANVFLAVN
40 51 LFLFLEKNIKN KLLFLLPISI IIWMVIHISM INIKFYKFEH QIKEQNISSI
101 TGVIKPHDSY NYVYDSNGYA KLKDNHRYGR VIRETPYIDV VASDVKNKSI
151 RLSLVCGIHS YAPCANFIK AKKPVKIYFY NQPQGD FIDN VIFEINDGKK
201 SLYLLDKYKT FFLIENSVCI VLIILYLKFN LLLYRTYFNE LE*

```

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

Example 19

The following partial DNA sequence was identified in *N.meningitidis* <SEQ ID 85>

```

1  ..ACCCCAACA GCGTGACCGT CTTGCCGTCT TTCGGCGGAT TCGGGCGTAC
50 51 CGGCGCGACC ATCAATGCAG CAGGCGGGT CGGCATGACT GCCTTTTCGA
101 CAACCTTAAT TTCCGTAGCC GAGGGCGCGG TTGTAGAGCT GCAGGCCGTG
151 AGAGCCAAAG CCGTCAATGC AACCGCCGCT TGCATTTTTA CGGTCTTGAG
201 TAAGGACATT TTCGATTTC TTTTATTTT CCGTTTTCAG ACGGCTGACT
251 TCCGCCTGTA TTTTCGCCAA AGCCATGCCG ACAGCGTGCG CCTTGACTTC
301 ATATTTAAAA GCTTCCGCGC GTGCCAGTTC CAGTTCGCGC GCATAGTTTT
55 351 GAGCCGACAA CAGCAGGGCT TCGCCTTGT CGCGCTCCAT CTTGTGATG

```

```

401 ACCGCCTGCA GCTTCGCAAA TGCCGACTTG TAGCCTTGAT GGTGCGACAC
451 AGCCAAGCCC GTGCCGACAA GCGCGATAAT GGCAATCGGT TGCCAGTAAT
501 TCGCCAGCAG TTTCACGAGA TTCATTCTCG ACCTCCTGAC GCTTCACGCT
551 GA

```

5 This corresponds to the amino acid sequence <SEQ ID 86; ORF124>:

```

1 ..TPNSVTVLPS FGGFGRTGAT INAAGGVGMT AFSTTLISVA EGAVVELQAV
51 RAKAVNATAA CIFTVLISKDI FDFLFIFRFQ TADFRLYFRQ SHADSVRLDF
101 IFKSFRACQF QFARIVLSRQ QQGLRLVALH LVDDRQLRK CRLVALMVRH
151 SQARADKRDN GNRLPVIRQQ FHEIHSRPPD ASR*

```

10 Computer analysis of this amino acid sequence predicts a transmembrane domain.

Further work revealed the complete nucleotide sequence <SEQ ID 87>:

```

1 ATGACTGCCT TTTGACAAC CTTAATTTCC GTAGCCGAGG GCGCGGTTGT
51 AGAGCTGCAG GCCGTGAGAG CCAAAGCCGT CAATGCAACC GCCGCTTGCA
101 TTTTACGGT CTTGAGTAAG GACATTTTCG ATTTCCTTTT TATTTTCCGT
151 TTTGACACGG CTGACTTCCG CCTGTTTTTT CGCCAAAGCC ATGCCGACAG
201 CGTGCACCTT GACTTCATAT TTTTAGCTT CCGCGCGTGC CAGTTCAGT
251 TCGCGCGCAT AGTTTGTAGC CGACAACAGC AGGGCTTGCG CCTGTGCGCG
301 CTCCATCTTG TCGATGACCG CCTGTGCTT CGCAAATGCC GACTTGTAGC
351 CTTGATGGTG CGACACAGCC AAGCCCGTGC CGACAAGCGC GATAATGGCA
401 ATCGGTTGCC AGTTATTTCG CAGCAGTTTC ACGAGATTCA TTCTCGACCT
451 CCTGACGCTT CACGCTGA

```

This corresponds to the amino acid sequence <SEQ ID 88; ORF124-1>:

```

1 MTAFTTLIS VAEGAVVELQ AVRAKAVNAT AACIFTVLISK DIFDFLFIFR
51 FQTADFRLEF RQSHADSVRL DFIFFSFRAC QFQFARIVLS RQQGLRLVA
101 LHLVDDRLLL RKRLVALMV RHSQARADKR DNGNRLPVIR QQFHEIHSRP
151 PDASR*

```

A corresponding ORF from strain A of *N.meningitidis* was also identified:

Homology with a predicted ORF from *N.meningitidis* (strain A)

ORF124 shows 87.5% identity over a 152aa overlap with an ORF (ORF124a) from strain A of *N.*

30 *meningitidis*:

```

          10      20      30      40      50      60
orf124.pep TPNSVTVLPSFGGFGRTGATINAAGGVGMTAFSTTLISVAEGAVVELQAVRAKAVNATAA
          10      20      30
orf124a      MTAFTTLISVAEGALVELQAVMAKAVNTTAA

          70      80      90      100     110     120
orf124.pep CIFTVLISKDIFDFLFIFRFQTADFRLYFRQSHADSVRLDFIFKSFRACQFQFARIVLSRQ
          10      20      30      40      50      60      70      80      90
orf124a      CIFTVLISKDIFDFLFIFRFQTADFRLEFRQSHADGVRLDFIFFSFTRLFQFAGVVLRSRQ

          130     140     150     160     170     180
orf124.pep QQGLRLVALHLDVDRQLRKRLVALMVRHSQARADKRDNGNRLPVIRQQFHEIHSRPPD
          100     110     120     130     140     150
orf124a      QQGLRLVALHFLNDRLLLRKRLVALMVRHRTQADKRDNGNRLPVIRQQFHEIHSRPPD

orf124.pep ASRX
orf124a      :
            VX

```

ORF124a and ORF124-1 show 89.5% identity in 152 aa overlap:

```

    orf124-1.pep  MTAFTSTTLISVAEGAVVELQAVRAKAVNATAACIFTVLISKDIFDFLFIFRFQTADFRLLFF
    orf124a      MTAFTSTTLISVAEGALVELQAVMAKAVNTTAACIFTVLISKDIFDFLFIFRFQTADFRLLFF
5   orf124-1.pep  RQSHADSVRLDFFIFFSFRACQFQFARIVLSRQQQGLRLVALHLVDDRLLLRKRLVALMV
    orf124a      RQSHADGVRLDFFIFFSFRTRLFQFAGVVLSRQQQGLRLVALHFLNDRLLLRKSRLVALMV
10  orf124-1.pep  RHSQARADKRDNGNRLPVIRQQFHEIHSRPPDASRX
    orf124a      RHRQTRADKRDDGNRLPVIRQQFHEIHSRPPDVX

```

The complete length ORF124a nucleotide sequence <SEQ ID 89> is:

```

1   ATGACCGCCT TTTGACAAC CTTAATTTC GTAGCCGAGG GCGCGCTTGT
51  AGAGCTGCAA GCCGTGATGG CCAAAGCCGT CAATACAACC GCCGCCTGCA
15  TTTTACGGT CTTGAGTAAG GACATTTTCG ATTTCTTTT TATTTCCGT
151 TTTAGACGG CTGACTTCGG CTGTTTTCG CGCAAAGCC ATGCCGACGG
201 CGTGGCGCTT GACTTCATAT TTTTAGCTT CCGCACGCGC CTGTTCCAGT
251 TCGCGGGCGT AGTTTGTAGC CGACAACAGC AGGGCTTGCG CCTGTGTCGG
301 CTTCAATTTT TCAATGACCG CTGCTGCTT CGCAAAGCC GACTTGTAGC
20 351 CTTGATGGTG CGACACCGCC AAACCCGTGC CGACAAGCGC GATGATGGCA
401 ATCGGTTGCC AGTTATTCGC CAGCAGTTT ACGAGATTCA TTCTCGACCT
451 CCGACGTTT GA

```

This encodes a protein having amino acid sequence <SEQ ID 90>:

```

25 1   MTAFTSTTLIS VAEGALVELQ AVMAKAVNTT AACIFTVLSK DIFDFLFIFR
51  FQTADFRLLFF RQSHADGVRL DFFIFFSFRTR LFQFAGVVLS RQQQGLRLVA
101 LHFLNDRLLL RKSRLVALMV RHRQTRADKR DDGNRLPVIR QQFHEIHSRP
151 PDV*

```

ORF124-1 was amplified as described above. Figure 7 shows plots of hydrophilicity, antigenic index, and AMPHI regions for ORF124-1.

Based on this analysis, it is predicted that this protein from *N.meningitidis*, and its epitopes, could be useful antigens for vaccines or diagnostics.

It will be appreciated that the invention has been described by means of example only, and that modifications may be made whilst remaining within the spirit and scope of the invention.

TABLE I – PCR primers

ORF	Primer	Sequence	Restriction sites
ORF 38	Forward	CGCGGATCCCATATG-TCGCCGAAAATTCCGA	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-TTTTGCCGCGTTAAAGC	
ORF 40	Forward	CGCGGATCCCATATG-ACCGTGAAGACCGCC	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-CCACTGATAACCGACAGA	
ORF 41	Forward	CGCGGATCCCATATG-TATTTGAAACAGCTCCAAG	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-TTCTGGGTGAATGTTA	
ORF 44	Forward	GCGGATCCCATATG-GGCACGGACAACCCC	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-ACGTGGGGAACAGTCT	
ORF 51	Forward	GCGGATCCCATATG-AAAAATATTCAAGTAGTTGC	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-AAGTTTGATTAAACCCG	
ORF 52	Forward	CGCGGATCCCATATG-TGCCAACCGCAATCCG	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-TTTTCCAGCTCCGGCA	
ORF 56	Forward	GCGGATCCCATATG-GTTATCGGAATATTACTCG	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-GGCTGCAGAAGCTGG	
ORF 69	Forward	CGCGGATCCCATATG-CGGACGTGGTTGGTTTT	BamHI-NdeI XhoI
	Reverse	CCCGCTCGAG-ATATCTTCCGTTTTTTTAC	
ORF 82	Forward	CGCGGATCCGCTAGC-GTAAATTTATTATTTTAGAA	BamHI-NheI XhoI
	Reverse	CCCGCTCGAG-TTCCAATCATTGAAGTA	
ORF 114	Forward	CGCGGATCCCATATG-AATAAGGTTTACATCGCAT	BamHI-NheI XhoI
	Reverse	CCCGCTCGAG-AATCGCTGCACCGGT	
ORF 124	Forward	CGCGGATCCCATATG-ACTGCCTTTTCGACA	BamHI-NheI XhoI
	Reverse	CCCGCTCGAG-GCGTGAAGCGTCAGGA	

TABLE II – Cloning, expression and purification

ORF	PCR/cloning	His-fusion expression	GST-fusion expression	Purification
orf 38	+	+	+	His-fusion
orf 40	+	+	+	His-fusion
orf 41	+	n.d.	n.d.	
orf 44	+	+	+	His-fusion
orf 51	+	n.d.	n.d.	
orf 52	+	n.d.	+	GST-fusion
orf 56	+	n.d.	n.d.	
orf 69	+	n.d.	n.d.	
orf 82	+	n.d.	n.d.	
orf 114	+	n.d.	+	GST-fusion
orf 124	+	n.d.	n.d.	

CLAIMS

1. A protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, and 6.
2. A nucleic acid molecule which encodes a protein according to claim 1.
- 5 3. A nucleic acid molecule according to claim 2, comprising a nucleotide sequence selected from the group consisting of SEQ IDs 1, 3, and 5.
4. A protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, and 90.
- 10 5. A protein having 50% or greater sequence identity to a protein according to claim 4.
6. A protein comprising a fragment of an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, and 90.
7. An antibody which binds to a protein according to any one of claims 4 to 6.
- 15 8. A nucleic acid molecule which encodes a protein according to any one of claims 4 to 6.
9. A nucleic acid molecule according to claim 8, comprising a nucleotide sequence selected from the group consisting of SEQ IDs 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85, 87, and 89.
- 20 10. A nucleic acid molecule comprising a fragment of a nucleotide sequence selected from the group consisting of SEQ IDs 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85, 87, and 89.
11. A nucleic acid molecule comprising a nucleotide sequence complementary to a nucleic acid molecule according to any one of claims 8 to 10.

12. A nucleic acid molecule comprising a nucleotide sequences having 50% or greater sequence identity to a nucleic acid molecule according to any one of claims 8 to 11.
13. A nucleic acid molecule which can hybridise to a nucleic acid molecule according to any one of claims 8 to 12 under high stringency conditions.
- 5 14. A composition comprising a protein, a nucleic acid molecule, or an antibody according to any preceding claim.
15. A composition according to claim 14 being a vaccine composition or a diagnostic composition.
16. A composition according to claim 14 or claim 15 for use as a pharmaceutical.
- 10 17. The use of a composition according to claim 14 in the manufacture of a medicament for the treatment or prevention of infection due to Neisserial bacteria, particularly *Neisseria meningitidis*.

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FIG. 1A

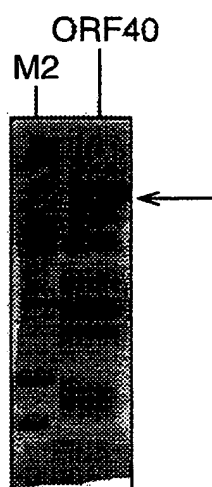


FIG. 1B

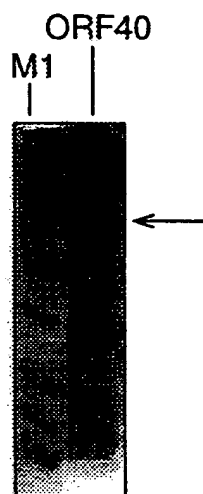
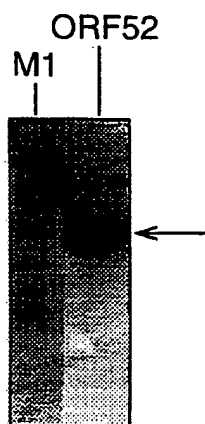
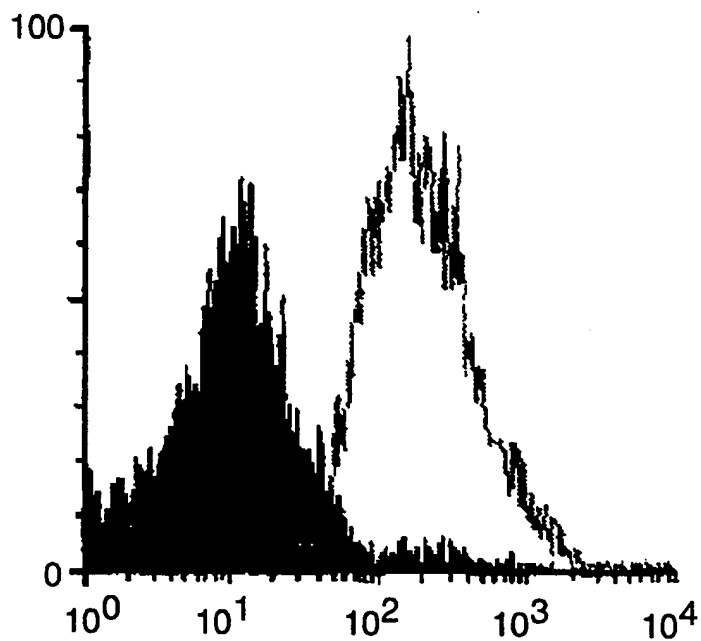
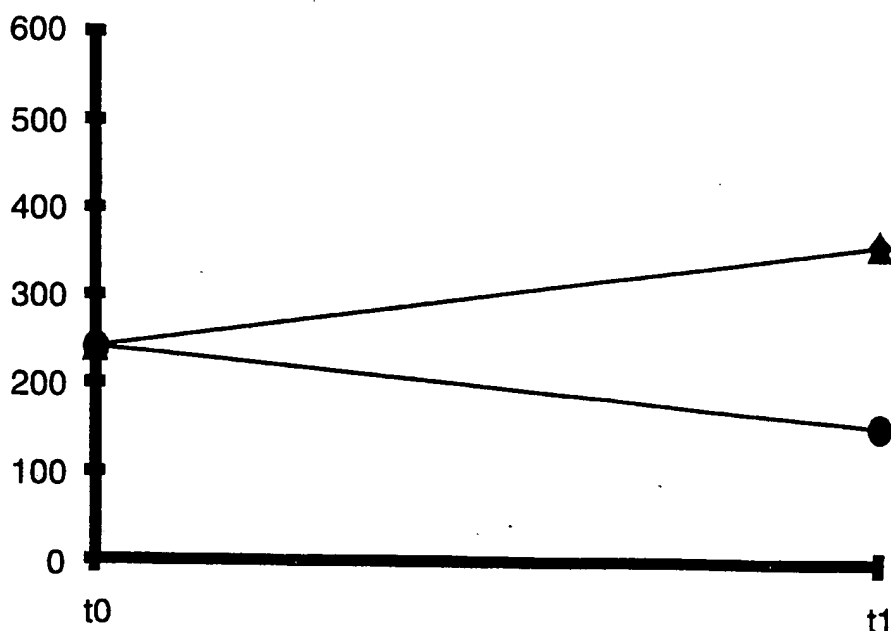


FIG. 4A



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**FIG. 1C****FIG. 1D**

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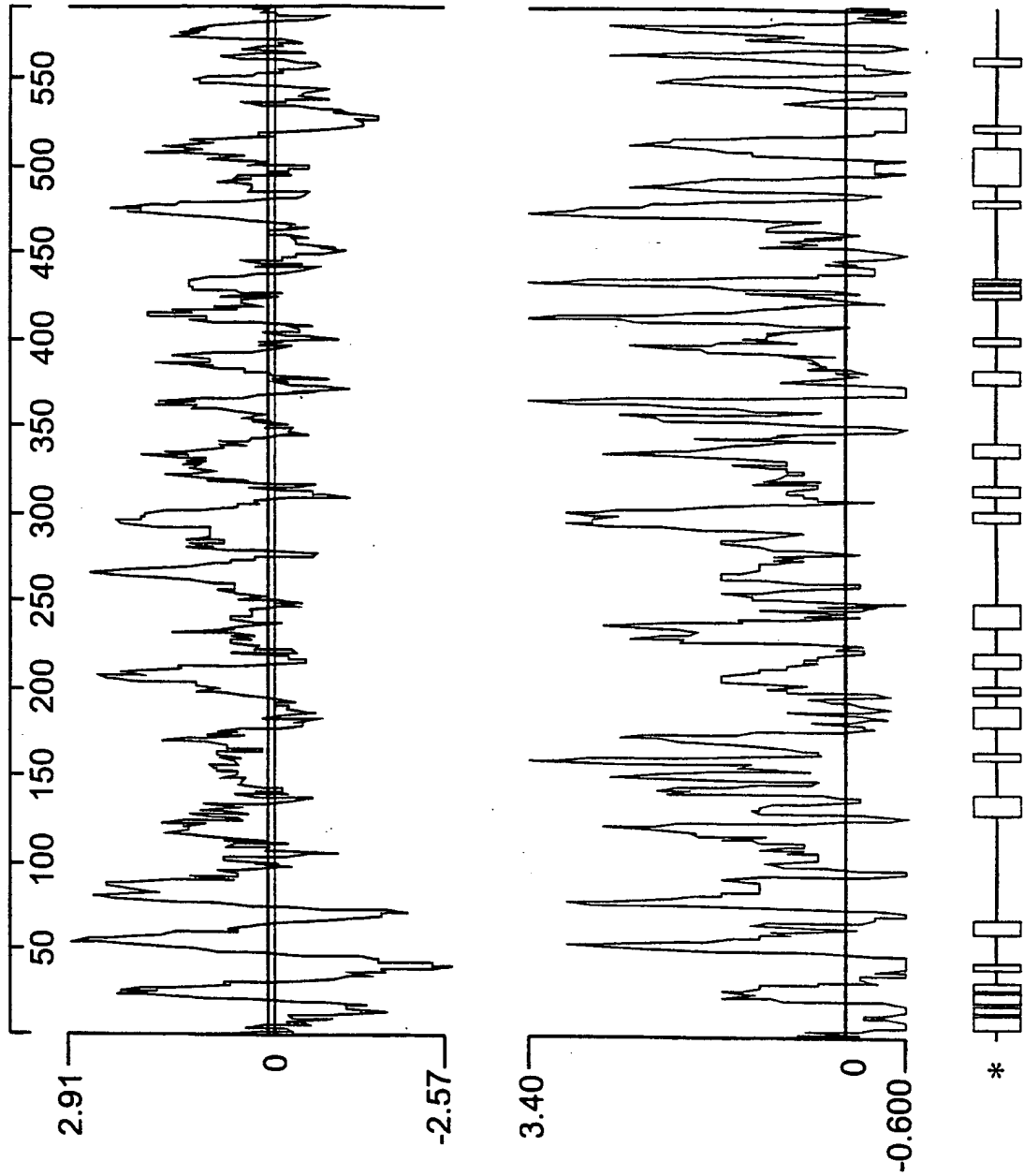


FIG. 1E

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FIG. 2A

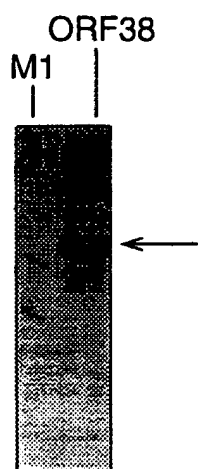


FIG. 2B

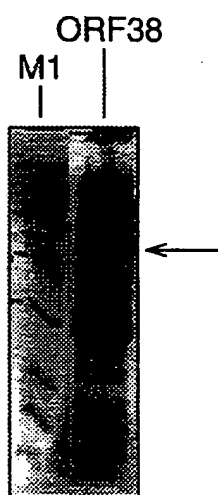


FIG. 2C

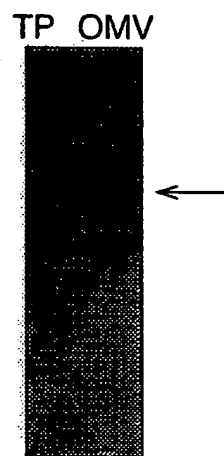
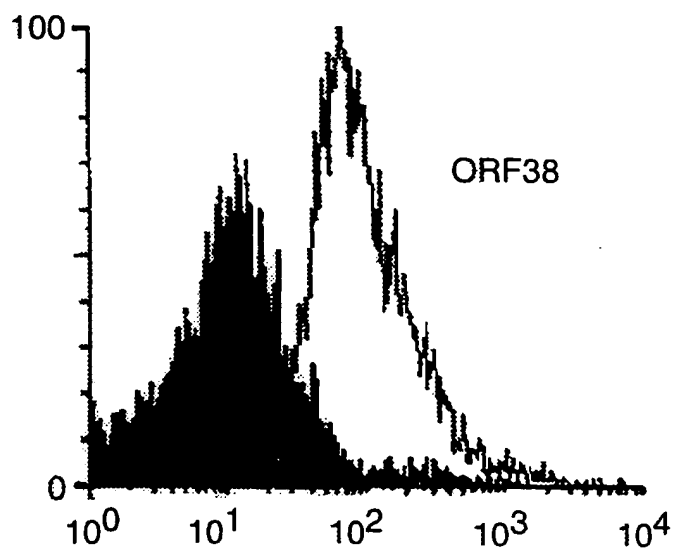


FIG. 2D



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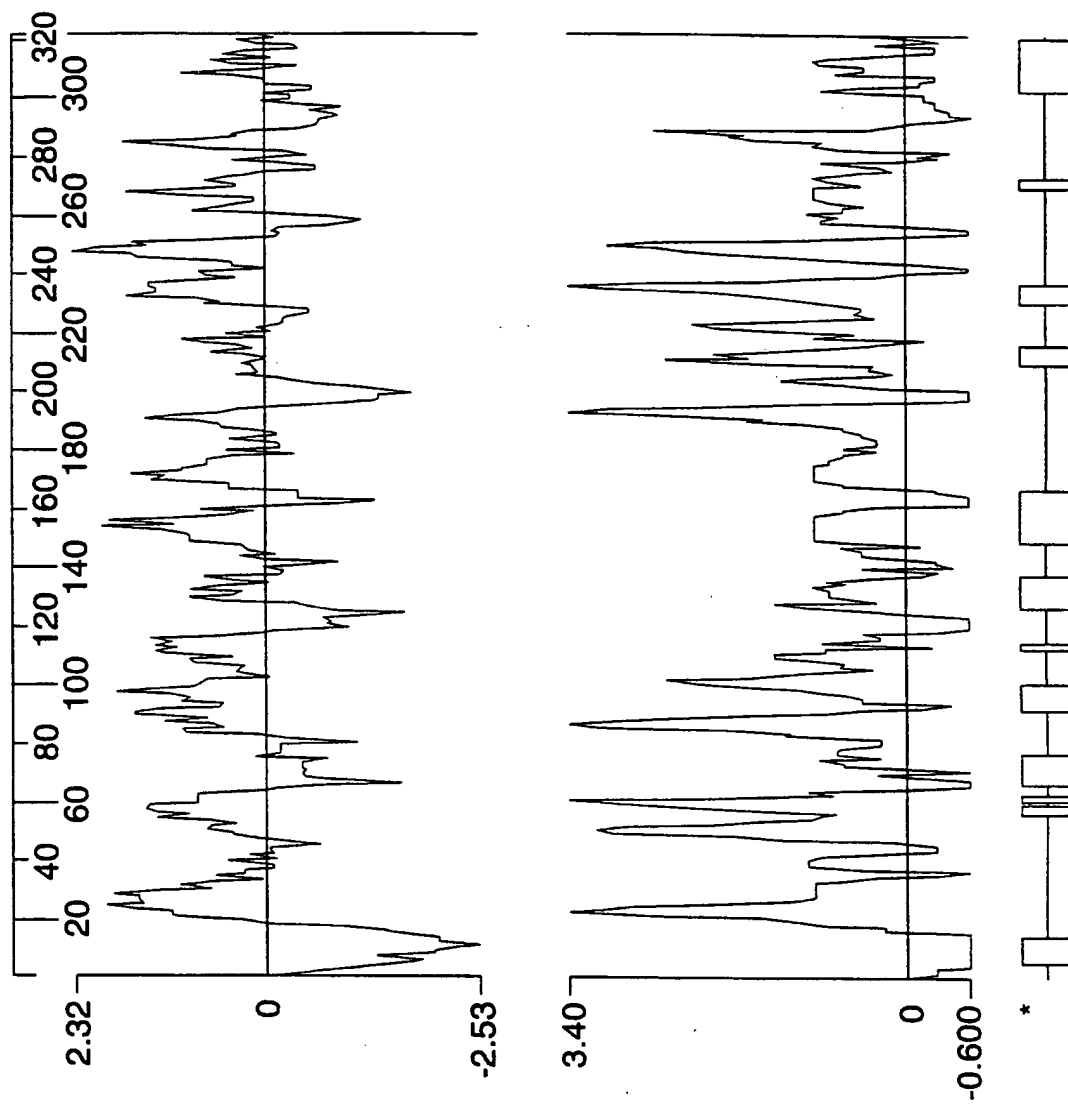


FIG. 2E

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FIG. 3A

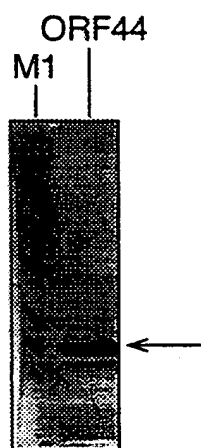


FIG. 3B

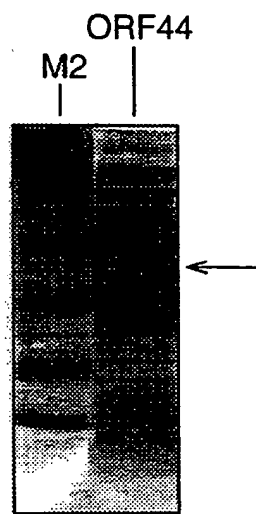
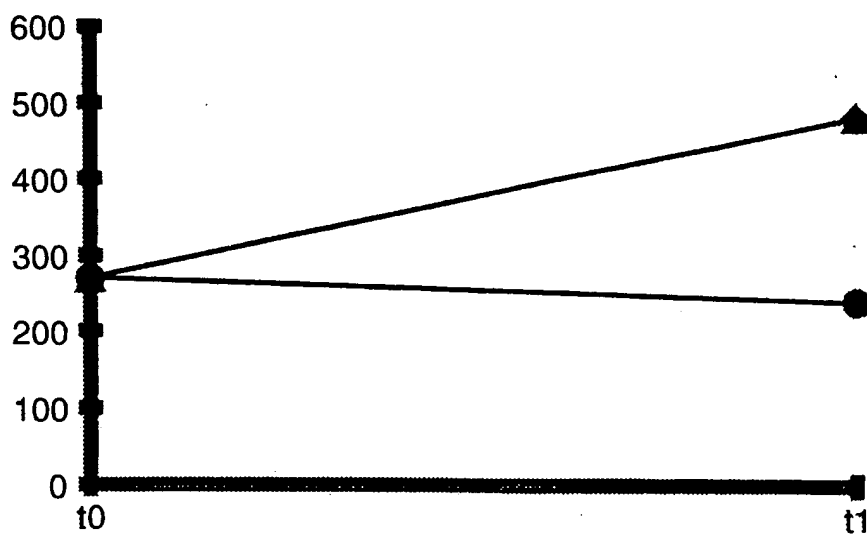


FIG. 3C



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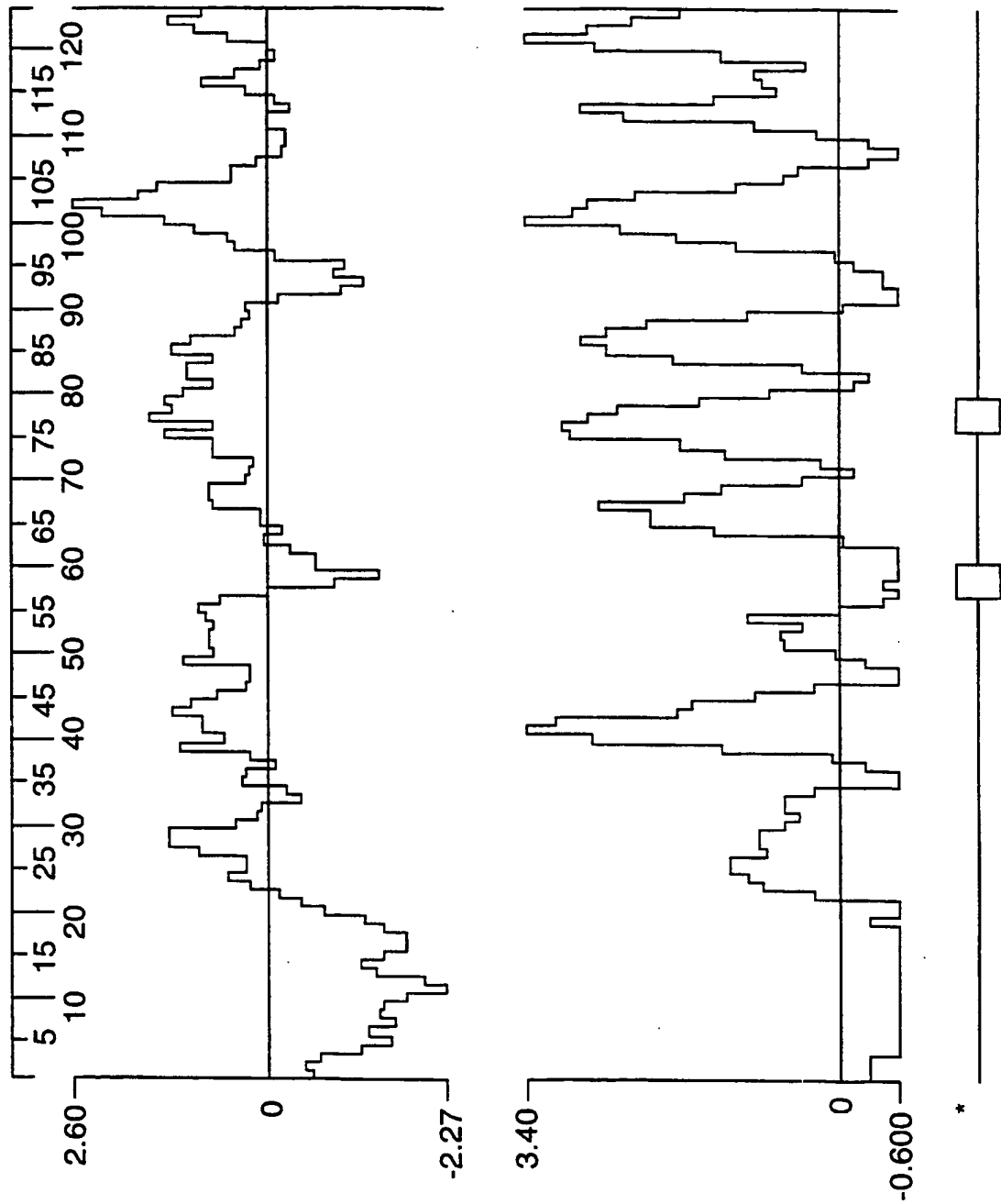
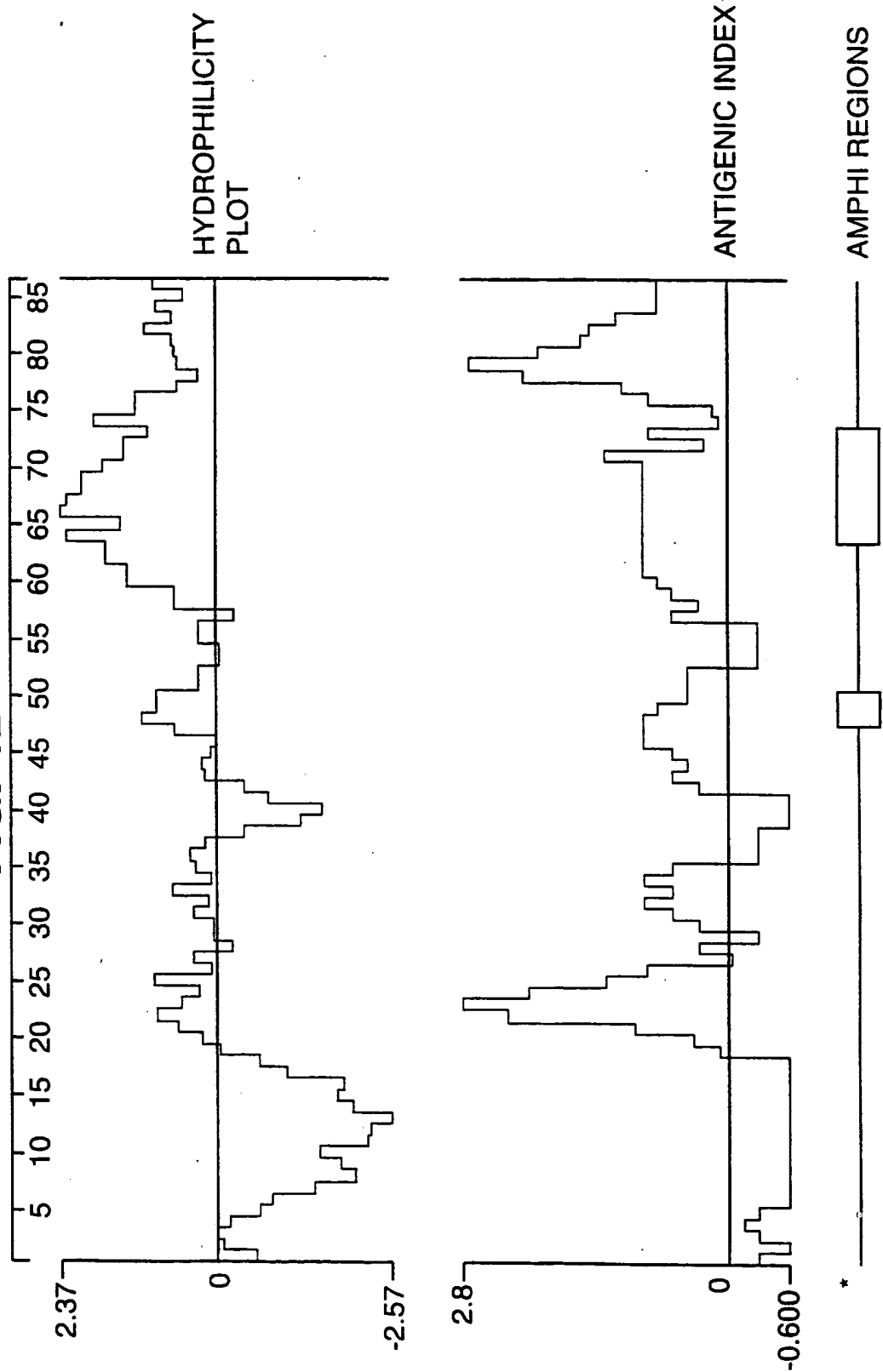


FIG. 3D

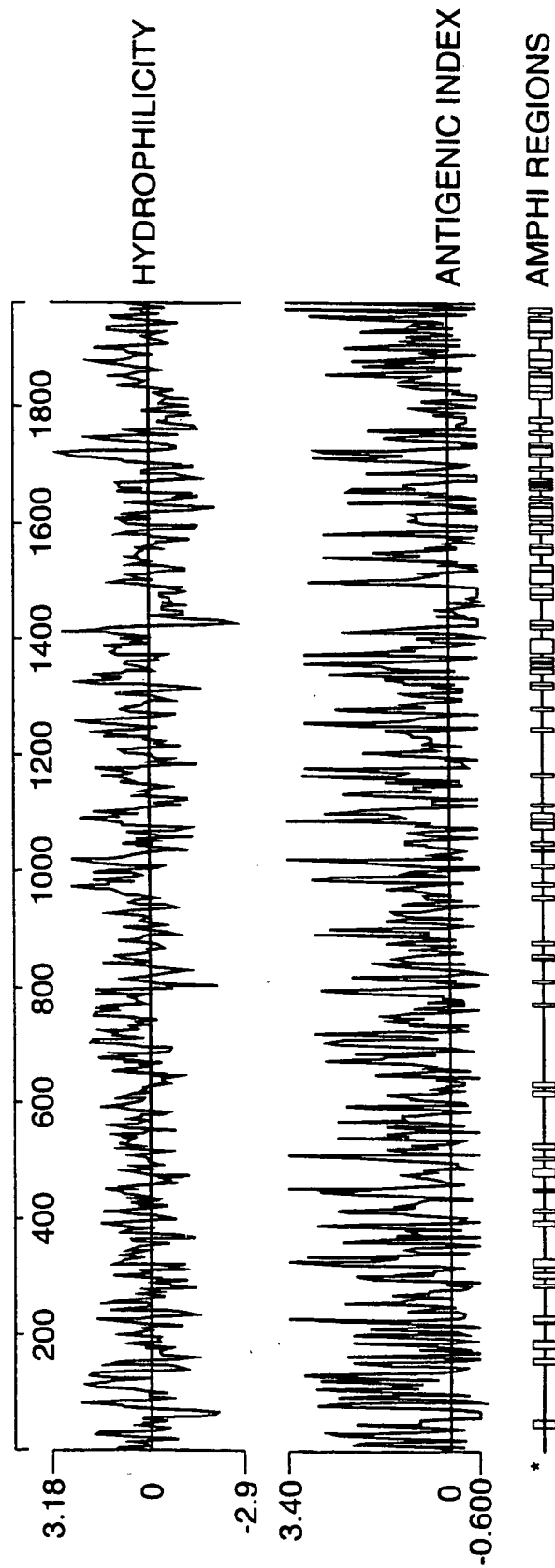
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FIG. 4B



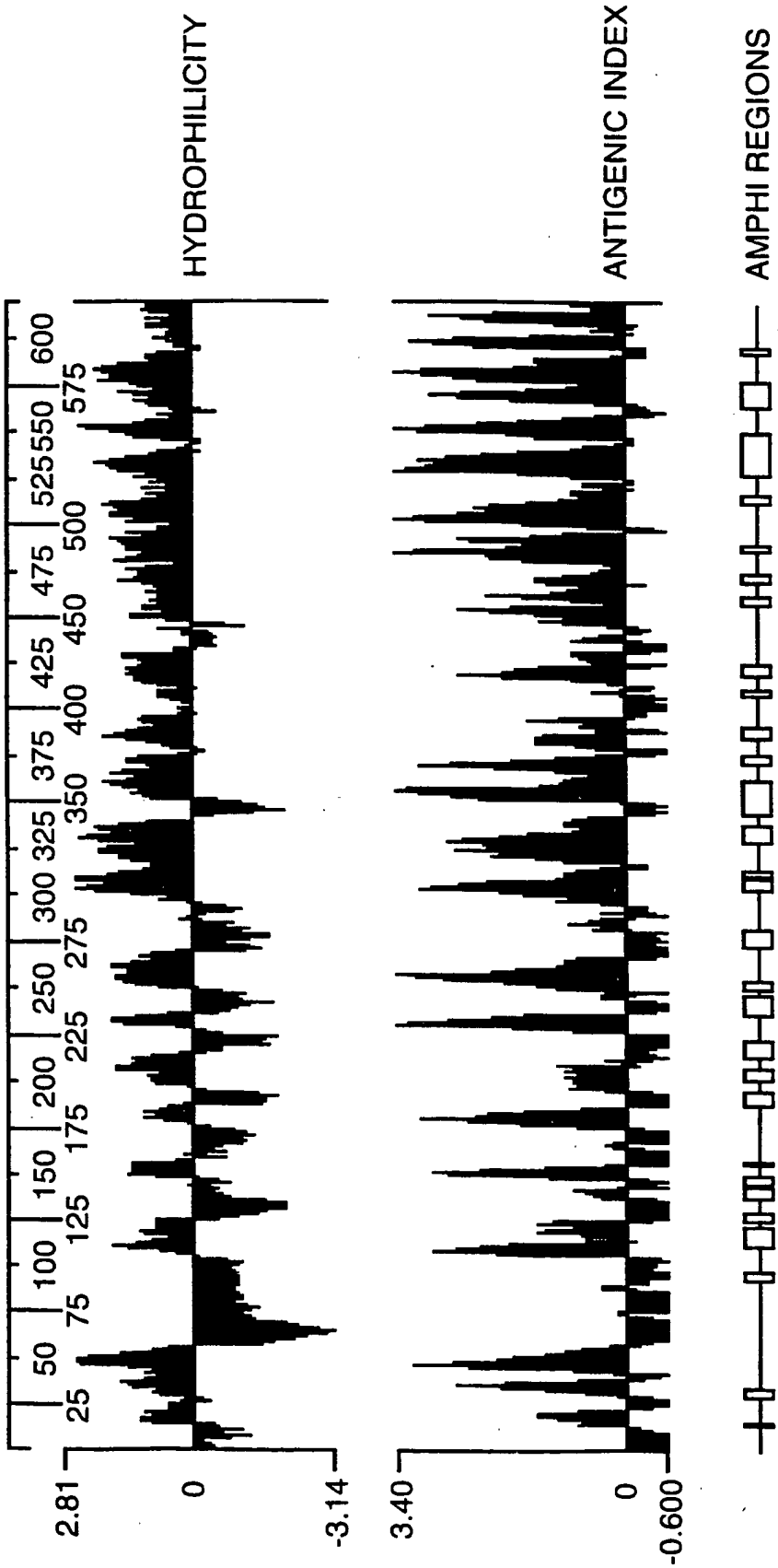
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FIG. 5



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FIG. 6



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FIG. 7

